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ON SCHOOLS: WITH PARTICULAR REFERENCE TO TRADES SCHOOLS.

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During a recent visit abroad, I had an opportunity of making some investigation into the subject of Trades Schools, particularly as they exist in the cities of Paris and London, and it has occurred to me that a digest of the information which I have obtained would add something to the growing interest that is being manifested in this department of education.

In connection with this matter my acknowledgments are due to Messrs. Drexel, Harjes & Co., of Paris, and also in London to Mr. James Forrest, Sec.Inst.C.E., Sir Frederick Bramwell, M.Inst.C. E., Mr. H. Graham Harris, M.Inst. C.E., Sir Philip Cunliffe Owen, Mr. H. Truman Wood, Sir Owen Roberts, Sir Edmund Hay Currie (by his repre-

sentative), and others, for their courtesies and attentions in enabling me to secure information, in obtaining for me papers, reports and other documents, and in doing everything in their power to aid my inquiries.

I have extracted very freely from documents, and reports whenever I deemed it necessary for my purpose, often using, without hesitation, the same language as therein contained, as most appropriate, without special acknowledgment and this general acknowledgment is intended to cover all such cases.

FRANCE.

Some of the documentary data to which I have had access is not as recent as desirable, but is perhaps sufficient for its purpose.

Elementary instruction in France, until within the last twenty or twenty-five years, was in a very backward condition, but of late the general and local governments have taken a great and increasing interest in the subject, and very marked improvements have been effected.

The average percentage of conscripts unable to read and write, amounting in 1833 to 47·8, shows a reduction in 1866–7 to twenty-three per cent., and in 1880, a still further reduction to fifteen per cent., the improvement being very decided in the great centres of industry. In the Department of the Seine, only 5·2 per cent. of illiterates existed in 1880 as compared with 6·7 per cent. in 1866; in the Department of the Rhone, 6·1 per cent., as against nearly ten per cent., and in the Marne District, seven per cent. as against eighteen per cent. This result has been owing to the state and local authorities assuming a larger proportion of the cost of primary education.

In 1867 the total number of children at the primary schools, excluding infants, was about 4,500,000, and in 1878–9 after the loss of Alsace and Lorraine, the number had increased to 4,950,000 out of a total population of about 36,900,000 (census of December, 1876). In 1866–7, the number of children paying no school fees was 1,617,000, while in 1879–80 it was 2,879,000.

Primary instruction is now gratuitous in Paris and in

most of the large provincial towns of France, as well as in many of the rural communes, and training-schools for boys have been established in all or nearly all the departments of France, also a number of training-schools for girls. There are in addition, higher colleges, in which teachers for these training-schools are prepared.

In Paris, free courses of elementary and advanced lectures are given on every branch of literature, art and science, including modern languages, social science, etc., delivered by men of ability, some of them having distinguished reputation, and standing foremost in rank in their respective departments. The audiences are largely composed of working people, and even the courses of the College de France and the Conservatoire des Arts et Métiers attract great numbers of working men and women. Similar courses of lectures are also given in most of the important towns of France, and in nearly all cases they are gratuitous.

The number of Art Schools in France is very great, nearly all being founded and conducted at the expense of the municipalities, and in Paris alone there are more than 100 adult art classes with excellent attendance, most of them being well provided with models and all needful apparatus. The instruction is gratuitous and an enormous majority of the pupils consists of working men.

There are in France a large number of shelter schools (Salles d'Asile), these schools containing in 1879–80, 606,000 children, five-sixths of whom received instruction gratuitously. These are hardly infant schools in our sense of the word. They afford shelter to children too young to attend primary schools and they are operated very much on the kindergarten system. Those who advocate the further development of manual work in the elementary schools, attach much importance to the training in these shelter schools. The manipulations necessary in the working of clay, the making of woven paper work and other operations connected with kindergarten instruction, develop the infant mind in matters of construction and accustom the child to delicate hand work.

The ordinary elementary schools take children from seven

to twelve years of age. There are three courses, elementary, intermediate and superior, the latter not to be confounded with the courses of instruction in the superior elementary schools (écoles primaires complementaires) and each division requires about the same period of time. Classes do not exceed forty or fifty pupils in number, and each class has its separate room. The hours of instruction are from 8 A.M. to 4 P.M., with one and a half hours' interval at noon, and one hour, 4 to 5 P.M. for gymnastics.

All of the instructions to a class are given by one master except for music, gymnastics and occasionally drawing, for the boys, and needlework for the girls. Pupil teachers, as assistants, are permitted by law but very rarely used.

In all French schools of every grade, corporal punishment is absolutely unknown.

Dinner (déjeûner) is taken in the school in most of the large cities, and kitchens are in some cases provided for the pupils to cook or warm special food themselves. It is said that in the poorer districts of Paris, a portion of the cost of the food is defrayed by the municipality, and in extreme cases even the books and clothing are provided.

The ordinary obligatory course comprises: Reading, writing, arithmetic, grammar, geography, the history of France, drawing and music, and this course is strictly carried out in all the large towns. In most of the large schools the elements of science are taught as object-lessons, and some of the schools have cabinets of minerals, botanical specimens, etc., nearly all of them possessing graphic illustrations of hysical and political geography, natural history, raw materials and manufactured products.

In quite a number of the primary schools of Paris, instruction in manual work has been introduced, comprising either the rudiments of a trade or an art, taught simultaneously with the ordinary elementary instruction, or the children are simply accustomed to the use of such tools as are commonly employed in working wood or iron, under proper teachers in the school building, but preferably out of school hours.

The primary communal school of the Rue Tournefort,

established in its present shape in 1873, was in 1882 the only school in France where rudimentary trade teaching was combined simultaneously with ordinary elementary instruction. At first the course of instruction in this school began with children at the age of ten years, and continued for three years, drawing, modelling, carving, joiner's work and smith fitter's work being taught during the first two years, and the work in the third year specialized. Since 1881, the same plan has been continued except that children in the lowest classes, beginning even at the age of six years, have had three lessons per week in handicraft, of one hour each. Although the third year is devoted to special work, yet the pupils in modelling and wood carving are obliged to return for *one day* in each week to joiner's and forge-work, while the joiners and turners return to the forge and modelling, and the smiths to modelling and joiner's work. This is intended to give to each pupil some knowledge of the other trades. The school hours are from 9 A.M. to 6 P.M., with half holiday on Thursdays. On Sundays the scholars are allowed to come to the school from 8 A.M. to noon, and from 1 P.M. until 4, for recreation or to listen to an entertaining lecture. In the highest classes thirteen hours work per week are given in the "shops" in addition to instruction in drawing, geometry and natural science.

It is stated that the reports of the inspectors relative to this school in 1881 or 1882, were not very satisfactory, and that the authorities had decided to confine themselves, in further experiments with the primary schools, to the teaching of more advanced drawing from models, and to the use of the ordinary tools employed in working of wood and iron, without attempting to teach the special trades, such instruction to begin only at the age of ten years and to be given before or after the usual school hours. Later reports state the school still continues in active operation and its working is entirely satisfactory, but the authorities have not yet been able to draw sufficient conclusions as to the effect of introducing manual teaching simultaneously with ordinary elementary instruction, to make any statement in favor of or against it.

There are, in most of the large towns of France, superior elementary schools for literary and in some cases technical instruction, in which, where not free, the charges are very low, only from seven to ten francs per month, even these being partially or wholly remitted to many pupils by means of scholarships granted for proficiency, etc.

The French "apprenticeship" schools are a peculiar type of superior elementary schools, in which technical instruction is combined with the other studies, the object being to form workmen as distinguished from foremen. One of these is the apprenticeship school in the large printing establishment of Messrs. Chaix & Cie, and another, the École St. Nicolas, in the Rue de Vaugirard, under the charge of the "Christian Brothers." The latter in 1881–2 had 720 ordinary scholars and 250 apprentices, all boarding in the school, and if the branches at Issy and Igny are included, upwards of 2,400 pupils. There is an entrance fee and an annual charge for instruction, the entering pupil passing an examination in reading, writing and the first three rules of arithmetic.

The studies are moral and religious; reading; writing; elements of history, of geography, and of the French language and literature; arithmetic; the elements of algebra and geometry; surveying; linear and ornamental drawing; modelling; book-keeping; elements of physics and chemistry; vocal and instrumental music; English, German and gymnastics.

The pupils enter the workshop at an average age of 14 years, and the parents apprentice them to masters or foremen of good character, selected by the Christian Brothers. The boys do their work at the school at the risk and for the benefit of the masters, the school receiving no profit and the boys no pay of any kind. The apprenticeship lasts three or four years, depending upon the kind of trade selected, and the boy can remain, after the expiration of his time, for one year longer as a journeyman, the master paying his board. There is a house under the patronage of the Brothers, containing club-rooms, library, and free classes in drawing, book-keeping, foreign languages, etc., where journeymen can be lodged and boarded on very reasonable terms.

The Christian Brothers continue to give instruction to the apprentices for two hours daily, not only in the ordinary school lessons but also in drawing, modelling and kindred subjects. The following trades are taught: Bookbinding, optical and mathematical instrument making, type-setting, printing, working and chasing in bronze, brass instrument making, gilding, joiner's work, saddle-making, wood-carving, wood-engraving, map-engraving and engine-fitting. Ready employment, it is said, is found for the apprentices after they leave the workshop, at wages varying from five to as much as eight francs per day.

This school still exists as a model establishment in every respect, the Paris buildings covering an area of over seventeen acres of ground, and its development has been aided by an issue of stock.

The school of Messrs. Chaix & Cie is also prospering, after having been in operation for twenty-five years. At the Exposition of 1878 it was awarded a medal.

At least fifteen or twenty years ago several of the municipalities of France gave consideration to the question of apprenticeship, and deemed it of sufficient importance to induce them to establish public apprenticeship schools, one of which, the "Municipal School of the Boulevard de la Villette," in Paris, for workers in wood and iron, has been in operation since January, 1872. This is one of the schools that I visited, and I will speak of it more in detail hereafter.

The success of this school was sufficient to warrant the authorities in deciding to establish a number of similar schools in various parts of the city. The whole subject was referred to a Commission, and its President, M. Tolain, in his report to the Prefect of the Seine, stated that in consequence of the virtual abolition of apprenticeship in most trades, and owing to the specialization and subdivision of manufacturers resulting from the introduction of machinery, the number of skilful and intelligent workmen in all branches of industry and art manufacture had steadily diminished, and that the standard of technical knowledge had been lowered. This threatened all the prosperity of French industry and more particularly the welfare of that

of Paris. The distinguishing merit of French manufacture has been in originality of design, but the applications of science and the introduction of machine tools has resulted in productions with a uniformity of character which diminished in a marked manner their artistic value, and facilitated piracy and foreign imitation. In view of this condition of affairs, the Commission recognized that "what was needed was not a system of technical education in favor of a privileged few destined to become foremen or managers of works, but to raise the standard of theoretical and practical technical knowledge among all classes of workmen." It was believed that the remedy lay in the establishment of professional apprenticeship or trades schools, under a system applicable to both boys and girls, the main object of these schools being not the creation of foremen, but the theoretical and practical education of workmen proper.

M. Tolain recommended the establishment of a school for the furniture trade, to produce workers of wood who would become cabinet-makers, upholsterers, carpenters, joiners or wood-carvers, etc., according to their natural aptitudes, also workers in iron intending to become general workers in metal for the same trades. He recommended a second school in the south of Paris on the model of La Villette for machinists and wood-workers, not for mechanics only, but for iron founders, carpenters, stone-cutters and masons, iron and tin-plate workers, slaters and plumbers; or, in other words, a thorough apprenticeship school for the building trades; also, a third school in the centre of Paris to combine the following specialties: scientific instruments, optical and mathematical instruments, telegraphic apparatus, small machinery, clock-making, surgical instruments, etc.

In addition to these three schools for boys, he recommended a school for girls, which should be not only an apprenticeship school, but also one of domestic economy, including general housework, laundry work, sewing, and to comprise in addition the obligatory parts of primary instruction, together with linear drawing, gymnastics, singing and some special notions of technology bearing on the duties of housekeeping and on the materials to be used in workshops.

The girls would be taught millinery, embroidery, lace-making, dress-making, artificial flower and feather-making, and there should be compulsory courses in drawing from flowers and nature, and in modelling.

The instruction in all of these schools was recommended to be gratuitous on admission certificates from the primary schools.

Apprenticeship schools of the same type as that of the Boulevard Villette had already been established in a few of the provincial municipalities, such as the school at Havre. There was also in France such establishments as the National Schools of Arts and Trades (Écoles des Arts et Métiers) turning out foremen or managers, but not workmen. In these schools the pupils are taught by working on objects not intended for actual use, and this was recognized as a great oversight, the work being sluggish and spiritless. Time seemed to be of no value, the foreman having no object in urging the pupils, as it only increased his own labors, and execution being the only point to be accomplished, irrespective of cost.

Where it is purposely intended to graduate only those who will become foremen and managers, the evil of this system is not so great, but for the education of workmen it is far more important. The investigations of the Commission showed that to give the pupils heart in their work it must be ordered and actually used. They must even be rewarded and pecuniarily recompensed. Other considerations also had important bearings on the case. Many of the families from which children are drawn are not well off, not to say poor, and not able to afford the maintenance of children up to sixteen and seventeen years of age, and to pay for their schooling besides. When the parents make sacrifices in the hope that their children will become first-class workmen, their hopes should not be disappointed. Payments for marketable goods could be used in rewards, thus encouraging the pupils and making, at the same time, some pecuniary recompense.

So reasoned M. Corbon, the reporter for the Commission, but the system adopted is, that, whenever a school receives

payment for a piece of goods manufactured, it pays it into the municipal treasury, which charges nothing to the school for the cost of the raw materials it employs. Certain difficulties would arise if the school were turned into a kind of a factory, selling goods at a profit. The best arrangement would be to open a credit for it, on the municipal treasury, for its expenses.

The report of the Commissioners further recommends that children of seven to ten years be taught very light work, all that can be done being to develop the manual dexterity of the child, and it should be given light tasks requiring little or no physical force, such work as drawing, cutting of patterns, joining together pieces of card-board, etc., in order to produce objects of various forms and colors, the "work at the same time fixing his attention and evoking his intelligence and ingenuity." "To these may be added the making of small objects in basket-work and trellis-work in wire, requiring the use of a light tool." Modelling should also be taught. It must be borne in mind that it is essential to employ the pupils in the genuine production of things that they can take home to show as their own handiwork, a few of the best of these productions, with the maker's name attached, can remain in the school museum as a nucleus for a collection.

"After ten years of age, some work in the shop could be introduced, if the instruction is suitably directed, and care is taken to allow weak and inexperienced pupils the use of only such tools as their muscular development will allow, and as would have no bad effect on the proper growth of the bodily frame. Children from eleven to twelve years of age may be made familiar with the majority of wood-working tools, the use of the turning lathe, and may learn how to hold and use a file. Skill and delicacy of manipulation can still be maintained by the practice of modelling in clay. At twelve years of age, the higher school may be entered, and in leaving this latter school at fifteen or sixteen years, the child will find himself in the most favorable condition either to enter a special professional school of the second degree, or to complete his training as a workman as rapidly as possible in the outside shop."

The Commission was of the opinion that "the handicraft instruction of the superior primary school should be based upon working in wood and iron. These two materials offer an almost illimitable field for that general preparation which the pupil ought to obtain, without any tendency towards specialization."

"Work in wood and iron should alternate, so that at the end of the year, the pupil should have been engaged in practical work in each of the two materials for two periods of sixty days each, in each of the two shops." "These two kinds of work would mutually supplement each other." "Having acquired a practical knowledge of wood-turning, the pupil could pass to metal turning, and, after completing the construction of any kind of wooden frame-work, he could more easily undertake the difficulties of joining metal work. Drawing in such superior primary schools should consist, in the first year, of drawing in outline and flat working, the special aim being to give precision in work and neatness in execution; in the second year, architectural drawing and ornament, combined with modelling, sketching, free-hand, being of the utmost importance; the third year to be principally occupied in sketching and the making of finished dimension drawings and sections of the different tools and machines used in the workshop, the students' works being exclusively executed after drawings made by themselves from such objects."

Such were the recommendations of the French Commission, of which M. Tolain was President.

I am not prepared to say as to the *entire* extent that these recommendations have been carried out, but I shall give, later, extracts from the compulsory education law as it now exists in France, and I shall now proceed to give statements as to the schools I visited in Paris as well as to others concerning which I obtained data but which want of time would not permit me to visit. All schools *visited* are so noted.

On the authority of a competent architect attached to the French Commission, of which M. Tolain was President, it was estimated "that the cost of establishing an apprenticeship school (without including the cost of the site) would

be a sum varying from, say, $360 to $400 per apprentice, according as the number of students varied from 100 to 300." It was stated, in the same connection, that "the class-rooms and amphitheatre could be so arranged as to accommodate a number of students attending evening classes, double that of the apprentices. For large and small tools an outlay of from $10 to $12 per apprentice would be necessary;" also, that "the school at Villette showed the annual expenditure of about $50 per apprentice."

L'ÉCOLE MUNICIPALE DIDEROT, APPRENTISSAGE, NO. 60 BOULEVARD DE LA VILLETTE (VISITED).

This is a professional apprenticeship day-school for boys, for workers in wood and metal, and intended to produce practical workmen in these materials. It was first opened in January, 1873, and is now under the charge of M. J. Bocquet, Ingenieur, as Director.

The course of instruction comprises eight departments, forging, turning in metal, light or "petite" mechanics, locksmith work, mechanics of precision, modelling, carpentry and joinery, and turning in wood.

The duration of the course of instruction is three years, and it is divided into general and technical. The general instruction, in addition to continuing those subjects which are obligatory in the primary schools, also includes some which are optional there, such as the elements of mathematics, physics, mechanics and chemistry in their relations to industry. In the early days of this school the error was committed of making this latter instruction too advanced, fatiguing the scholars and rendering them inattentive, but this trouble has now been corrected.

The theoretical instruction also comprises explanations concerning the tools, the materials, the processes and the products as embraced in the course of practice given in the workshops.

During the summer months, various industrial establishments are visited and the students are obliged to give accounts of these establishments in writing.

The trade instruction in the workshop consists of two

courses. In the first, the pupils are taught the nature and the conversion of materials, and in the second, they pass on to actual construction. The first or preparatory course is given in the first year, and is the same for all the pupils. They pass successively through the workshops for both wood and metal, without any question as to which special trade will be selected. This is done in order to give "suppleness and certainty" to the hand and to enable the boy when he becomes a workman to take up, at least for a time, in case of need, a different trade from that which he adopted and thus to gain a living if the times should be bad for his own trade. The boy is also given an opportunity of deciding in his own mind which trade he likes best.

The choice of trade is made with the approval of the parents, at the beginning of the second year, and now the second course commences, in which the pupil goes into actual construction work. The day's work comprises five and one-half hours in the workshop for the first two years, and seven and one-half hours for the third year; four hours in the school classes for the two first years and three hours for the third year. The two kinds of exercises are separated by an interval for meals and recreation.

Military exercises are given on every Thursday between 1 and 3.30 P.M., from the beginning of the school-year until Easter, and between 4.30 and 6.30 P.M. from Easter until the examination at the end of the year.

The instruction is gratuitous and the students are furnished, free of charge, with all means and implements for study and work. No student is admitted before the age of thirteen years or after sixteen years, and admission is only after an examination which takes place at the school, every year, during the month of August. This examination comprises:

(1) A dictation.

(2) A problem in arithmetic on the rule of three.

(3) A problem in fractions or finance.

(4) A calculation of surface or a volume with the application of mensuration.

(5) A free-hand sketch and a sketch drawn to dimensions.

The entry papers of candidates are received at the school every day from the 1st of May until the day of examination, between the hours of 8 in the morning and 4 o'clock in the afternoon. Children of families living in the suburban communes have a right to admission in the professional schools of Paris, by obtaining a certain rank in competition, on the condition, however, that the suburban communes acknowledge the children and become responsible for the payment of 200 francs yearly for each child.

The candidate must bring with his application the necessary legal documents, exemption papers, etc., to show that the parent has fully complied with all laws in reference to military service; his certificates of primary studies, if he possesses such, and a copy of his certificate of birth.

After the examination, a list of the students is posted outside as well as inside of the school building, and the parents are obliged to sign a register prepared for the purpose in order to retain places for their children. The parents must also furnish, at their own expense, a school uniform, a school uniform cap, the only head covering allowed during the whole course of the school, and a working costume, consisting of a blue jacket and blouse. Every Monday the student must come in a fresh or clean costume.

The school hours begin at 7.30 A.M. for students of the first and second years, and at 6.45 A.M. for those of the third year. All classes are dismissed at 7 in the evening.

Students are not allowed to leave the school during the day under any pretext. They can take their mid-day meal in the room provided for the purpose, at a charge of one-half franc for each day that they are there, bringing their food and drink with them, and breakfast scholarships are accorded in great numbers to studious pupils of the second and third years.

Any student absenting himself from the morning course of studies is not allowed to take the exercises in the afternoon. All absences must be authorized by the Director, and those not duly authorized or justified, merit punishment; if they occur too frequently, the Administration, at the suggestion of the Director, may expel the pupil.

The following is the general programme of the exercises and studies at the École Municipale Diderot:

PROFESSIONAL INSTRUCTION.

DEPARTMENTS OF TRADE.	FIRST YEAR.	SECOND YEAR.	THIRD YEAR.
Forging.	During the first year, the apprentices pass successively through the iron and wood-working shops, in order that they may discover practically to which class of work their taste and aptitude leads them.	Preliminary exercises, tools, welding.	Forging of pieces of machinery.
Turning of Metals.		Tool working and adjustments of tools, turning of simple pieces; boring.	Adjustment of arbors and borings; cutting of screws and tools; screw-cutting by hand.
"Petite" mechanics.		Tools, adjusting and turning of small pieces.	Small tools and machines, demonstration models.
Locksmith.		Tools, keys, locks, locksmiths' work in buildings.	Ornaments, leaves, flowers and other artistic locksmiths' work; assembling.
Instruments of precision.		Preliminary exercises, tools, chasing, by machinery and by hand work.	Physical and telegraphic apparatus.
Modelling.		Modelling of simple parts of machines.	Machine tools, gearing, loam boards, core boxes.
Carpentry and joinery.		Tool sharpening, joints, assembling; various kinds of framing.	Doors, sashes, furniture, erecting.
Wood turning,		Mounting and adjusting of tools, handles and simple pieces, screw-cutting by hand.	Turning of patterns for castings; turning of twisted and square work.

THEORETICAL INSTRUCTION.

DEPARTMENTS OF STUDY.	FIRST YEAR. Divisions A and B.	SECOND YEAR. Divisions A and B.	THIRD YEAR.
French languages.	Grammar, orthography.	Completion of course in grammar. Exercises in composition.	Reports of visits to shops and factories.
Mathematics.	Arithmetic, plane geometry, first three books, applications.	Completion of course in arithmetic, geometry, measurement of surfaces surveying, measuring and levelling.	Elementary algebra, elements of geometry of solids, measurement of volumes bounded by the usual curved surfaces.
Chemistry.	Elements of general chemistry.	Industrial chemistry. Metallurgy.	Completion of courses in physics and chemistry.
Physics.	Elements of physics. General proportion of bodies.	Industrial physics. Applications.	
Technology.	Materials; their origin, properties and applications. Hand tools.	Elementary parts of machines; methods of designing machines.	Description of machine tools. Steam motors, small motors.
Mechanics.		Elementary machines. Applications.	Completion of course in mechanics. Resistance of materials.
History.	Outlines of general history up to modern times.	History of modern times; scientific and industrial discoveries	Completion of course in mechanics. Resistance of materials.
Geography.	Geography of Asia, Africa, America and Oceanica (commerce and industry).	Geography of Europe, and in particular that of France. Commerce and industry.	Completion of course in mechanics. Resistance of materials.
Ornamental drawing.	Free-hand drawing from models in plaster, cast and wrought iron or wood.	Free-hand drawing from models in plaster. Principles of ornamental composition.	Completion of course in mechanics. Resistance of materials.
Geometrical drawing.	Free-hand sketches. Full size drawings.	Free-hand sketches from models. Drawing from sketches. Full sizes.	Measurements of tools and machines, free-hand sketches from models in wood or metal Drawings from sketches Full size geometrical drawings.
Book-keeping.			Elements of book-keeping and political economy.

A certificate of apprenticeship is given after the end of the third year, but those students that do not pass through the third year are not given certificates.

The following table shows the manner in which the daily studies and exercises are divided up, as in practice several years ago. Some modifications from this may have been made, but if such is the case, they are most likely not very great. I therefore give the table, as it may prove useful for reference in arranging like studies in other schools.

TIME-TABLE ÉCOLE MUNICIPALE DIDEROT.

Day.	Years.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to 12.	Observations.
Monday,	1	Preparation of lessons.	French.	Sketches.	Preparation of lessons.	English.	
	2		Mathematics.	Preparation of lessons.	English.	Physics.	
	3		Mechanics.	Chemistry.	Workshops.		
Tuesday,	1	Preparation of lessons.	Technology.	Preparation of lessons.	Sketches.	Geography.	
	2		History.	French.	Preparation of lessons.	Mathematics.	
	3		Sketches and drawing.		Workshops.		
Wednesday,	1	Preparation of lessons.	History.	French.	Preparation of lessons.	Mathematics.	
	2		French.	Preparation of lessons.	Sketches and drawings.		
	3		Technology.	Mathematics.	Workshops.		
Thursday,	1	Preparation of lessons.	Physics.	French.	Preparation of lessons.	English.	
	2		Geography.	Preparation of lessons.	English.	Chemistry.	
	3		Sketches and drawing.		Workshops.		
Friday,	1	Preparation of lessons.	Chemistry.	Drawing.	Preparation of lessons.	Mathematics.	
	2		Technology.	Preparation of lessons.	Sketches and drawings.		
	3		Preparation of lessons.	Mathematics.	Workshops.		
Saturday,	1	Preparation of lessons.	Preparation of lessons.	Mathematics.	Preparation of lessons.	Descriptive Geometry.	
	2		Mechanics.	Preparation of lessons.	Descriptive Geometry.	Mathematics.	
	3		Physics.	Common Law.	Workshops.		

For all the three years. { 12 to 1, lunch and recreation. / 1 to 3½, workshops. / 3½ to 4, meal and recreation. / 4 to 7, workshops. }

From 10 minutes to 10 until 5 minutes past 10 there is a quarter of an hour's recreation for all the boys.

The school is supervised by a council composed of one of the chief school inspectors of Paris, the director of the school and the superintendent of the workshops.

The school will accommodate 350 boys.

I noticed in going through the building three forges in the blacksmith shop and quite a large number of lathes in the machine shop, with some boring and planing machines, the boiler and engine being at one end of the shop. The boys take turn about at the engine and boiler, eight-day shifts. Several of the machines, including a boring machine, were pointed out to me as made entirely by the pupils. In the carpenter shops there were about fifteen wood-turning lathes and forty-eight or fifty carpenter benches. Every boy has his own separate bench, the benches being arranged endways to the wall of the room, with a reasonable space between benches. This is the universal custom of arranging the benches in the French schools so far as I saw them.

There is one room devoted to instruments of precision, and some beautiful work was shown; cubes, parallelopipedons, etc., where the exact uniformity of dimensions appear in like parts under the most careful measurements. In this department we saw measuring instruments, electrical instruments and tools of various kinds, all made by pupils, and giving evidence of most careful and exact work. There is a room for hand-work on metal and one for filing work alone. We were shown a number of special parts of machines made by the pupils, keyed work, etc.

M. J. Oudinot, who has special charge of the Department of Instruments of Precision, has issued a publication on the subject, which might be useful to any one contemplating the teaching of similar work.

Class-rooms, dining-rooms, etc., are placed in buildings adjoining the workshops, but there is nothing special to record concerning them.

Each student is obliged always to make a working drawing, to a proper scale, for any piece of work he proposes doing, before he commences it, so that he may become thoroughly acquainted with its proportions and connections, understand fully the nature of what he is doing, and carry out the work in strict accordance with his drawing.

The general conduct of this school is reported to be good, although it has been necessary to exclude some boys for insubordination.

In addition to the rewards ordinarily allowed in French schools, the students are given others, such as fortnightly premiums varying from twenty-five centimes to three francs, prizes of books, tools and articles manufactured in the school.

The absentees do not exceed about seven per cent., including what is due to sickness, and the irregularity generally occurs in the first year. The health of the boys is very good. In five years previous to 1882, not one boy had died.

The school commenced in January, 1873, with 17 scholars; the number increased the following year to 64; in 1881, there were 250, and in 1889, 350.

A considerable number of boys leave after the first year, because the parents discover that they have not the ability for further work; a small number after the second year because the parents are not willing to lose their earnings in a business or trade for a longer time. Those who have passed two years in the school can generally command fair wages in second-rate shops.

In reference to the choice of trade in the school, the fitters far outnumber any of the others, those for one year selected being about fifty per cent. of the total number, and the smiths come next. These two trades appear to command the highest wages in Paris.

L'ÉCOLE D'AMEUBLEMENT RUE DE REUILLY, NO. 25 (VISITED).

This is a Municipal apprenticeship school for boys, to teach carpentry, cabinet-making and upholstery. It has now only temporary quarters in an old building, with frame additions for workshops.

The Director stated that the best example existing in France of this type of school was the "École La Martiniere at Lyons," founded in 1867, of which an account will be given hereafter.

The first room into which we passed was the dining or

breakfast-room, provided with tables and stools, andalso coat-hooks around the walls for the boys' caps and coats. We then went into the museum, intended for purposes of object teaching, and containing, besides other objects, quite a large collection of the various materials used in upholstery.

In the carpenter shop the work benches are about 6½ feet long, 18 inches wide and 2 feet 8 inches in height above the floor, all arranged pretty close together. In the cabinet shop the benches are somewhat smaller, being about 5 feet 6 inches long. They are provided with a vise and the usual appendages to such benches. The rooms contain quite a large number of wood-turning lathes. The frames of such chairs and other furniture as are required in the upholstery shop are made in the cabinet department. Not only is the practical work of upholstery taught, but the art of designing, grouping and arranging hangings, etc., so that those who go out from this school are not only workmen, but artists in their profession, thus keeping up the reputation for which French workmen have always been famous.

The course of this school is four years in length. Wood-carving is taught in the third and fourth years, and some very fine and excellent work is turned out. The best pupils make and carry out their own designs entirely. There is a drawing-room where all drawings are made, and a modelling room for making models. Each pupil in the carpentry and cabinet shop must make a working drawing of the object before he commences work upon it. In carved work, the pupil first makes his design on paper, then he makes a clay model and a plaster cast from it; finally he works from the cast. Some of the best pupils, in their last year, are allowed to work out their carvings directly from their own conceptions, designing as they go, without drawings or models, but only first-class artists can do this. I saw some work being done in this way, and it only goes to show what excellent workmen graduate at this school. I also saw some pupils working their designs directly in the clay without drawings. It is stated by the Director that those who graduate at this school go out *as first-class workmen.*

In reference to designing, all the different styles, such as Gothic, Renaissance, etc., are taught, and the pupils study some chemistry, sufficient to cover their special work.

A gymnasium attached to the establishment, provides for special training, adapted to the trades which are taught. I saw a class going through the exercises, and was particularly impressed with the great care shown by the teacher with his pupils.

It struck me that upholstery would be an important trade to teach in Philadelphia, and that, with the exception of some of the heavier work connected with it, it was well adapted to girls.

[*To be continued.*]

"THE FIRE DEFENCES OF PARIS AS COMPARED WITH THOSE OF AMERICAN CITIES, AND ESPECIALLY OF PHILADELPHIA."

By W. L. BOSWELL,
Delegate of the INSTITUTE to the Paris Exposition.

[*Report made to the* FRANKLIN INSTITUTE *at the Stated Meeting, held November 17, 1889.*]

The specific object of my appointment being the examination of such new inventions as might be exhibited at the Exposition, for guarding against fires or securing their prompt extinction, my attention was naturally first turned in this direction. It was safe to infer that any means or invention of this kind could not fail to find its place in the Exposition. But repeated and thorough examination, failing to reveal anything of the kind, the question became a different one; and as the mathematician, who reaches a negative result, only feels called upon to make a re-statement of his problem, so the real question became, why is this field of invention left unworked? These appliances became only more conspicuous by their absence.

In answering this question, we must first see if there is the same necessity for fresh appliances or fresh methods in Paris as with us. Taking as authorities for most of the

statements that follow, the Report of the Firemen of Paris made to the Police Department, of which they are a part, the last Report of the Insurance Patrol of this city, and the Report of the Chief Engineer of the Bureau of Fire, also of this city, we reach the following comparative statements.

Nearly two-thirds of all the fires in Paris during last year were chimney fires, which were extinguished without difficulty and with no material loss, and may therefore be disregarded. Besides these the fires in 1888 in Paris were 923, as against 762 in Philadelphia.

As to the gravity of the aggregate losses last year, we find as follows:

Fire loss in Philadelphia,	$2,128,155
Fire loss in Pennsylvania,	5,102,402
Fire loss in the United States:	
Insurance Loss,	52,677,896
Total Loss,	119,209,380
Fire loss in Paris,	1,322,742

The average fire loss in the United States for the last thirteen years has been about $90,000,000 a year.

The difference between the insurance loss and the total loss in the United States arises from the fact that in the cities and large towns the loss by fire is generally borne by the insurance companies, so that in Philadelphia, for example, the discrepancy may be disregarded; but taking the whole country together, it amounts, as appears above, to more than one-half the entire loss. From an examination of these figures we reach the following result: that *in proportion to population, fires are twice as numerous in Philadelphia as in Paris, and four times as destructive.* On comparing the fire loss in Philadelphia with that in the United States, we find a ratio remaining from year to year nearly the same; which results, partly from the size of the city, and chiefly from the varied character of the industries here carried on. In no other city is there so great variety; and if we ascertain the fire loss in this city, we can, within reasonable limits, find the loss in the United States. So that we must enlarge our view and reach the inevitable conclusion that our national loss by fire in proportion to population, is more than four times that of Paris.

In view of these facts, we are driven to inquire the reason of this discrepancy, a question eminently proper for consideration by this INSTITUTE, which seeks the fullest practical results from scientific investigation.

Let us examine, therefore, more in detail the nature of fire hazards and the means adopted for guarding against them.

Hazards are of two kinds, physical and moral.

Physical hazards are such as arise, first, from the character of the building, a low, brick building with metal or slate roof is always safer than a high, frame structure with shingle roof; secondly, from the character of the occupancy; a gunpowder factory will always be more hazardous than a warehouse for the storage of pig-iron; thirdly, from exposure, a building adjoining a distillery will always be more hazardous than one adjoining a graveyard; fourthly, from difference in the means for the detection and extinction of fires, an efficient fire department amply supplied with water, will always give a lower insurance rate, because of diminished hazard. These illustrations are, of course, extreme cases, but in the large intervening ground the inspection of hazards and determination of rates is a work demanding obviously the amplest experience and observation, and the closest attention.

The second class of hazards includes what are called moral hazards; hazards dependent on the owner, being entirely personal in their character. Here is an element of danger generally disregarded by the public, chiefly perhaps, for the reason that its value cannot be scientifically ascertained.

The ratio of fraudulent claims in Paris has been set down on good authority as twenty per cent., and an American underwriter, of large experience, has given his opinion that the ratio in this country is fifty per cent. While no reliance can be placed upon these exact figures, as being only matters of opinion, yet they sufficiently show that the intelligent underwriter must make large allowance in the determination of hazards, for the personal element; must consider whom he insures, rather than what he insures. The extent of this

element may be best shown perhaps by considering the times at which fires occur. And for this purpose I have prepared plates giving the hours of the occurrence of the fires of Paris during last year. In all scientific investigations the scientist is distinguished from the sciolist by the manner of his investigations; the sciolist experimenting to see what results will follow in a blind way; the scientist to see if his prevision of results is sanctioned and correct.

Before examining Plate I, which gives the Paris fires for last year, and bearing in mind that this plate refers only to the frequency of fires, and not to their gravity, which is conditioned largely by causes outside of the present inquiry, let us see what we should naturally expect would be the times of the occurrence of fires.

We should expect to find that in the forenoon fires would increase for several hours with a pretty steady ratio; then that they would decrease about mid-day, then that they would increase in the afternoon, decreasing again about four or five o'clock; from which time they would increase until they reached a maximum about eight to nine o'clock at night, after which time they would decrease with considerable regularity until they reached the minimum about six to seven in the forenoon.

There are three times when fires are most frequent; from ten to eleven in the morning, three to four in the afternoon, and eight to nine at night, the number at this last time being very greatly in advance of those during the daytime. The reasons why the fires should be greatest at night from eight to nine, are obvious; as well as those which bring more frequent fires at certain times in the forenoon and afternoon. If we now turn to Plate I, we find these expectations corroborated by the result; the fires in the forenoon and the afternoon, being largely exceeded by the fires of the night, and the fire line going with reasonable regularity from the maximum at night to the minimum at six o'clock in the morning. Now the fires from six o'clock in the morning to nine o'clock at night, in their relative frequency, are susceptible of a physical explanation, but after that time, the causes of fires have generally ceased, and if there were

no element but the physical danger, there would be but few fires during the night and early morning.

The attempted explanation by attributing such fires to spontaneous combustion is worthy only of passing notice. It requires but little chemical knowledge to pronounce such spontaneous combustion, under the circumstances that are generally found, to be a scientific impossibility.

Let us look now at Plate II, in which are given the fires of Philadelphia as to frequency. In the first plate the fires in Paris were 923; the fires in Philadelphia in Plate II are as given by the Insurance Patrol, and as they only attended last year 285 fires, it is necessary to take also the fires attended by them in 1887, 281 in number, and marked on the chart by a broken line. This will give us an aggregate of more than 500, enough to guarantee us in determining the law. It will be noticed in these that the fire line in the two years was reasonably the same, with such variation as would rather confirm the accuracy of the statistics on which it is founded. On examining this plate we find the same lines within reasonable limits for fires in the forenoon and the afternoon, as we found in the plate representing the fires of Paris. We find, as before, that the maximum of fires was at eight to nine at night, but from that hour on to the early morning we no longer find a tolerably regular decrease in fires, but a broken line, indicating serious fire dangers in the latter part of the night.

In this respect the fire line of Philadelphia is in violent contrast with that of Paris. These irregularities in the fire line in the latter part of the night are susceptible but of a single explanation: as being due to moral hazards rather than physical. While it would be most unjust to indulge suspicion in any particular case of the integrity of the assured, whose premises were destroyed during the night, yet the result reached by the aggregate is such as no scientific investigation can disregard. In this moral hazard there is included not only the danger of arson, but the general danger from neglect. So far as insurance interests are concerned, there is a regular gradation from the man of honor, pursuing a profitable business, down through the

various degrees of unsuccessful labor to where financial failure so often leads to arson. It is not in human nature for a manufacturer to have no more solicitude for a factory yielding a large and steady income than of one that annually brings him in debt; nor will the merchant watch so vigilantly over an antiquated stock, the market value of which has fallen far below the insurance, as if his own money were at stake. Hence moral hazard is largely conditioned by the profitableness of the building or the business. The number of those who actually fire buildings for the sake of gain is small, but the number of those who become negligent of an unprofitable store or factory is very great, and so far as the hazard is concerned, neglect and carelessness are nearly as dangerous as gunpowder, and when there is added the certainty of immediate pecuniary profit from the fire, the mischief is largely increased.

Now as against these dangers, thus hastily sketched, what means in Paris have been found most effectual? The first remedy is found in the substantial character of the buildings, with strong partition walls in each, and the care specifically taken to prevent fires. But as this matter will be more fully discussed by another delegate, I will not dwell here any further upon it.

A second advantage in Paris is that stores and factories are not separated by such great intervals from dwellings. One of the loneliest places in New York City is among the warehouses on the east side, and few persons who have not been in the neighborhood of the large stores and warehouses of this city late at night, can be aware how easily a fire may start and make considerable progress before its detection. So much is this recognized that a store occupied partly as a dwelling has a reduction made in the rate on that account.

A third advantage in Paris is its complete distribution of fire appliances, which make it impossible for a fire to continue any length of time. Ten dollars, expended for the prevention of fires, or their detection in their incipiency, are worth more than a thousand dollars in the means for their extinguishment. There is a regiment of more than

1,700 trained firemen, with well-equipped stations in every part of the city, and with such ample provision as enables them to fight any fire that may occur. In this service the *esprit de corps* is maintained by diplomas of honor and by gold and silver medals awarded for signal service. In one station I found in the hall on a mural tablet of black marble the names of those who had perished in the service.

A fourth advantage in Paris is the small amount of water used in extinguishing a fire; the chief reliance being placed upon water buckets, of which the fire department has more than 10,000. Last year buckets were used in 698 fires out of 923, and steam engines only thirty-seven times; that is, more than two-thirds of the fires were extinguished by the use of buckets, and, in only one case out of twenty-five were steam engines used. In this city we have thirty-five engines, of which six were purchased last year, throwing each 700 gallons of water per minute. In proportion to population there should be in Paris at this rate nearly 100; but in fact, there are only twelve. The free use of water here may be absolutely necessary, and so justifiable, but any one who thinks what would be the result of two such engines throwing 1,400 gallons of water per minute, can easily realize that the chief benefit of the effort has been not to save the building or its contents where the fire originated, but to prevent the fire from extending to contiguous buildings.

A fourth help in Paris is the necessity for the assured to give to the proper authorities, within fifteen days of the fire, a full account, giving:

(1) Day and hour of fire.
(2) Its duration.
(3) Its cause.
(4) Means used for its extinction.
(5) All circumstances about it.
(6) Nature and extent of the loss.

A further advantage in Paris is in the fact that insurance is made with what is known as the co-insurance clause. I attach so much importance to this as to desire to call your attention more fully to it. By it the loss borne by the

insurance companies bears to the total loss the same proportion that the insurance bears to the value of the property at risk. That is, let:

x = loss to insurance companies.
L = total fire loss.
I = total insurance.
V = value of property; then,

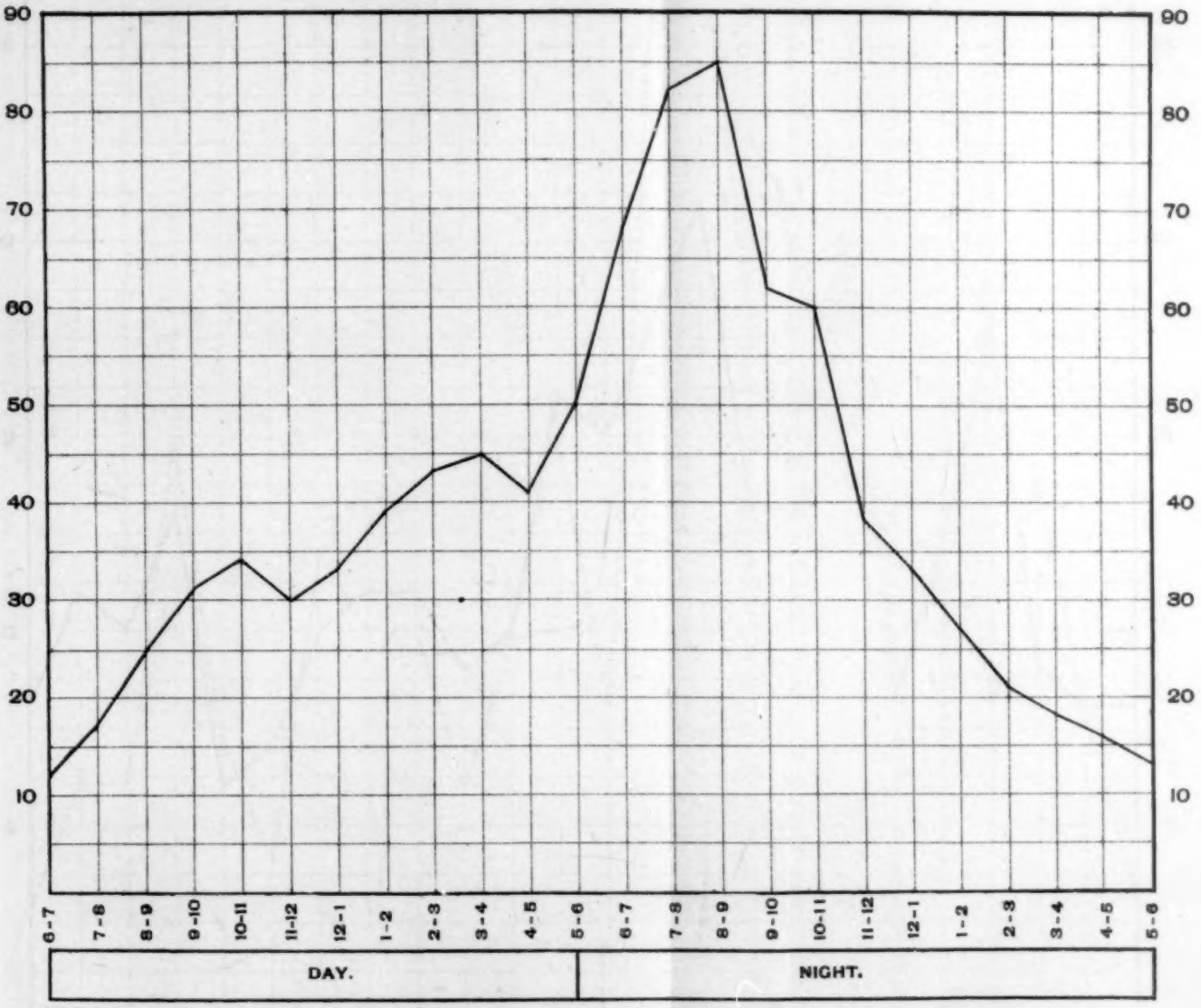
$$x : L :: I : V \text{ or } x = I\frac{L}{V}$$

As in any particular case L and V may be regarded as constants, we have x, a function of I. To illustrate the application of this rule, suppose a stock of goods worth $100,000 is insured to the amount of $50,000; then should the fire destroy goods to the value of $50,000, the insurance companies would pay $25,000 only, and the balance would be borne by the assured himself. By the custom of this country of leaving off the co-insurance clause, the insurance companies in the case supposed would pay the entire loss, and the assured himself bear no part of the loss. The reasoning in Paris is very simple and plausible. If only half a stock is insured, how can it be determined whether a fire has burned up the half that was insured or the other half? If there be a defalcation in a bank, beyond its own means to remedy, so that depositors suffer, why should the loss fall upon one depositor more than another? Without going into the question on equitable grounds, it is evident that the responsibility resting on the assured would be immensely increased by such a clause, and the increased care that would result on the part of the assured would make it possible to largely reduce the rate of insurance. Although most insurance experts would perhaps regard it as excessive, yet in my own opinion, the general introduction of this clause in American insurance would justify a reduction in rates of fifty per cent., and this opinion has been reached by study of the question for a number of years.

Still again in Paris there is a responsibility in the case of fire that is almost ignored here.

The first recourse, as it is called, is of the tenant against

Fires in Paris in 1888—Total Number 923.



The Figures on the Sides Indicate the Number of Fires at the times marked on the bottom.

the landlord, who is responsible to the tenant if it can be established that the fire was from some defect in the construction or maintenance of the building.

The second recourse is the reverse, for the tenant is responsible to the landlord for any damage to the building sustained by fire caused by the negligence of the tenant.

The third recourse is the remedy which one has against his neighbor; for he on whose premises the fire has occurred is responsible to his neighbors on both sides for any loss that may occur to them in consequence. While, at least in some States, these liabilities are recognized here, yet generally, except in the case of railroad companies, they are not in force. Probably in Paris they would be neglected more than they are, but for the fact that it is common to effect insurance, not only on one's own property, but to cover these additional liabilities. In the event of fire, therefore, no sympathy with the assured prevents the course of justice. The matter is in the hands of the different insurance companies representing the different interests, and it is a simple business arrangement to enforce legal liability and thus protects the interests of the assured.

I have thus briefly stated the relative condition of Paris and Philadelphia as regards fires, with the causes that underlie the differences, and the possible remedies that will come to us in time. In this I have remembered that the guiding policy of this INSTITUTE for more than half a century has been to combine the most rigid scientific investigation with the amplest economic results.

On the Latent Heat of Vaporization of some very Volatile Substances.*

By James Chappuis.

Translated by Chief Engineer Isherwood, U.S.N.

There are very few numerical data relative to the latent heat of ebullition of the liquid substances which become gaseous at temperatures below 0°.

Favre has given the results of his experiments on sulphurous acid, on the protoxide of azote, and on solid carbonic acid; his method allows the direct measurement of the latent heat of evaporation of the liquids at their temperature of ebullition under the atmospheric pressure.

The researches of Regnault were made on a very great number of substances; but we know under what circumstances the *procès-verbal* of his experiments were destroyed in 1870, and that he found and published consequently only the numerical results relative to ammonia and to liquid carbonic acid. The method he has described is general and allows the latent heat of ebullition at various temperatures between 0° and + 25° to be obtained, but the calculations are extremely complicated; in particular, the heat absorbed by the expansion of the vapor often formed a considerable part of the total heat observed.

The method that I have applied to the chloride of methyl, to sulphurous acid, and to cyanogen, and which I intend to apply to other substances next winter, is based on the employment of the ice calorimeter of Bunsen, and allows the determination with a relatively sufficient precision of the latent heats of ebullition at 0° under the maximum tension corresponding to the melting point of ice. This

* *Comptes Rendus*, 1887, p. 897.

method avoids the effect of expansion and, consequently, all the correction required for it.

The essential part of the apparatus is composed of a glass cylindrical reservoir closed at the bottom and containing the liquid to be evaporated. This recipient is surmounted by a coiled capillary tube having a considerable length in a small height and being soldered to an ordinary escape pipe the free end of which is solidly cemented to a cock having a steel pointer, forming thus a lateral tubulure.

The recipient being two-thirds filled with the experimental liquid, is weighed and placed in the Bunsen calorimeter where it and the coil are surrounded with mercury. The experiment is conducted like an ordinary calorimetrical experiment. The cock with the pointer is opened at the proper moment and the vapor escapes from the apparatus, an escape pipe conducting it into the oil whence it emerges bubble by bubble. It had to traverse the coil whose length is not less than 0·30 metre, taking the temperature 0°; it expands to the opening of the steel tube which is separated from the calorimeter by a glass tube about 0·15 metre long. As regards the unavoidable diminution of pressure in the interior of the apparatus, that diminution can be made as small as desired by generating the vapor with corresponding slowness.

The cock being again closed, we watch, in order to withdraw the evaporating apparatus, until the movement of the mercury in the calibrated tube, maintained at 0°, becomes again regular, and we have obtained the readings necessary for the correction of the displacement of the mercurial column.

The variation of the weight p of the evaporating apparatus does not measure the weight ω of the liquid transformed into vapor, but the weight of vapor that has passed out of the instrument; the relation, however, which exists between these two numbers is easily calculated. The difference of the weighings before and after the experiment, gives, in fact, the difference between the weight of the liquid transformed into vapor and the weight of the satu-

rated vapor which occupies the same volume, whence is easily concluded that

$$\omega = p \frac{d_l}{d_l - d_v}$$

d_l and d_v being the weight of unity of volume of the liquid and of the vapor at 0° under the maximum tension of the experimental liquid at that temperature. The first of these numbers is known for several of the liquefied gases; the second if it has not been directly measured, can, without inconvenience, be calculated by the general formula for the densities of vapor.

If by m be designated the volume at 0°, corrected for the mercury gone out of the calorimeter, the latent heat will be given by the formula—

$$L = A \frac{m}{\omega}$$

in which A is a constant in common for the different Bunsen apparatus I have employed, having the value 1·13322. The graduated tube allows a measurement of 0·02 cubic millimetres. The weights were made to the half milligramme. Under these conditions there could only be an error of some thousandths which could reach consequently only to the first decimal of the numbers representing the latent heats.

In the manner above described, I have obtained the following results:

		Latent Heat in Calories.
Chloride of methyl. $C_2 H_3 Cl$,	Maximum, 96·8 Minimum, 97·1	Mean, 96·9
Sulphurous acid. SO_2, . . .	Maximum, 91·3 Minimum, 91·9	Mean, 91·7
Cyanogen.* Cy, ...	Maximum, 103·5 Minimum, 104·1	Mean, 103·7

I will give in the next memoir the details of these experiments which could not find place here, and I will show:

(1) That the speed of the experiment; or, in other words,

* The density at 0° of liquid cyanogen not being known, I have not been able to calculate ω, and I had to use p for the calculation of L: the number 103·7 is consequently too great by probably half a calorie.

the weight of substance vaporized per minute, has considerable influence on the result. While that speed was comprised between eight milligrammes and sixteen milligrammes per minute, the values of L were constant, which they ceased to be when the speed was comprised between twenty milligrammes and sixty milligrammes per minute.

(2) In the case where the speed of vaporization is comprised between the above limits, the temperature of the evaporating apparatus does not fall below — 0·3°.

ON THE LATENT HEAT OF VAPORIZATION OF SOME VERY VOLATILE SUBSTANCES.*

By James Chappuis.

Translated by Chief Engineer Isherwood, U.S.N.

I have described in a preceding note† the method I employed for the determination of the latent heat of some liquified gases, applied first to the chloride of methyl, to cyanogen, and to sulphurous acid. It has led me to fix the latent heat at 0° under the maximum tension corresponding to the melting point of ice, for the sulphurous acid in particular at 91·7 calories.

Since I published this result it has been confirmed by the investigations of Messrs. Cailletet and Mathias.

The experimental determination made by them of the two kinds of densities of sulphurous acid, and the knowledge of the variation of the elastic force, measured by Regnault, between — 30° and + 65°, enable the heat of vaporization to be calculated by the well-known formula—

$$L = \frac{T}{E}\left(\frac{1}{d_1} - \frac{1}{d_v}\right)\frac{dp}{dt}.$$

This calculation gives for the latent heat at 0°, 91·2 calories. The agreement between these two numbers is very satisfactory.

* *Comptes Rendus*, 1888, p. 1007.

† *Comptes Rendus*, 1887, p. 897.

I have since applied that method to carbonic acid, taking the constant necessary to the calculation from the investigations of Messrs. Cailletet and Mathias of the densities of the liquefied gas and its saturated vapor, namely—

$$d_l = 0{\cdot}9083$$

$$d_v = 0{\cdot}0975$$

Consequently—

$$\frac{d_l}{d_l - d_v} = 1{\cdot}12025,$$

and the latent heat at 0° can be calculated by the formula—

$$L = \frac{1}{1{\cdot}2695}\,\frac{m}{p}$$

The mean of the experiments made with very variable speeds of vaporization, but generally slow to avoid expansion, gives—

$$L = 56{\cdot}25 \text{ calories.}$$

The thermodynamic formula, which has already been used in the case of sulphurous acid, enables the latent heat of carbonic acid at 0° to be calculated.

If there be substituted for the letters the numbers furnished by the investigations of Mr. Sarrau, there results—

$$L = 55{\cdot}95 \text{ calories.}$$

With the numbers taken from the curves which represent the experiments of Messrs. Cailletet and Mathias, there can be calculated the value—

$$L = 57{\cdot}48 \text{ calories.}$$

Finally, by aid of the formula—

$$L^2 = 118{\cdot}485\,(31 - t) - 0{\cdot}4707\,(31 - t)^2$$

proposed by these physicists to represent the variations of the latent heat of carbonic acid with the temperature, there is found—

$$L = 56{\cdot}75 \text{ calories.}$$

The number given by direct experiment is thus found almost exactly on the curve representing the calculated latent heats.

A TEST OF AN OTTO GAS ENGINE.

EDGAR KIDWELL and EDWIN R. KELLER.

[*Contributed by the Mechanical Engineering Department of the University of Pennsylvania.*]

The following article is an abstract of a test made by Messrs. Kidwell and Keller for a graduating thesis in the Department of Mechanical Engineering.

The engine had been in use for a long time without overhauling by the makers, but was in fair average condition. The admirable set of experiments, conducted under the auspices of the Society of Arts, the results of which were published after these experiments were made, seemed to make it unnecessary to publish the entire record and work of the test, but as some of the results are worked out in a somewhat different way, a short account of the test and its results may be of interest.

H. W. SPANGLER, U. S. Navy,
Asst. Prof. Mech'l Eng'r'g.

METHODS.

The engine experimented on was a seven horse-power (nominal) Otto type engine. The volume of the cylinder and clearance space was determined by filling with water and found to be ·439 cubic feet for the total volume, and ·1796 cubic feet for the clearance space, leaving ·2594 cubic feet for the volume swept through by the piston each stroke.

The gas used during the test was passed through a large meter, and thence through rubber bags to the cylinder, a portion passing through a second meter, being taken from the same supply for the jet.

The pressure of the gas used was taken by a manometer, attached to the supply pipe, and the absolute pressure of the gas was found by adding to this reading that of the standard signal service barometer. The temperature of the

gas was taken as that of the room, the meter, bags and pipes being practically entirely within the room. Samples of the gas were taken for analysis. The amount of cooling water used was weighed, by allowing it to discharge in a vessel for periods of ten minutes during the test, the water running at practically the same quantity per minute throughout the entire test. The temperature of the water before and after leaving the cylinder jacket was taken by thermometers placed as shown in *Fig. 1*, which also shows the position of a Brown's pyrometer placed in the exhaust pipe of the engine. The length of pipe between the cylinder and pyrometer was carefully covered with asbestos board, preventing radiation to a great extent.

The power developed in the cylinder during each explosion was determined from a mean indicator card constructed as described below, the power given off by the engine being absorbed by a friction brake on the fly-wheel.

The speed was taken every five minutes by a revolution counter and stop-watch.

It was found necessary to limit the duration of the tests to one hour at a time because of the heating of the fly-wheel. The engine was started and allowed to run an hour; the brake was then put on, and after the engine had settled down to steady condition the test began. It was continued for an hour, the brake was removed, and the engine kept running until the wheel cooled down, when the brake was replaced and another set of observations made. The total duration of the tests, that is, the actual time during which the observations were made, was three hours, ten minutes.

APPARATUS.

The thermometers used were made by Henry J. Green, of New York, and read to degrees Fahrenheit. The pyrometer used was made by Edw. Brown, of Philadelphia, and was graduated at intervals of 10° to 1,200° F. The revolution counter used was of the endless-screw and wheel type, reading to single revolution. The stop-watch read to one-fifth second. The meters used were a large one, made by the Goodwin Meter Company, for gas-engine tests, and

an ordinary seven-light meter made by the same company. The scales for weighing the water read to $\frac{1}{100}$ pound.

The apparatus used for analyzing the gas was an Elliott apparatus, similar to that used at the International Electrical Exhibition in 1884.

A Crosby indicator, with a 100-pound spring, was used throughout the test.

The bulbs of the thermometers used for measuring the temperature of the jacket water were inserted in thin metal cups screwed into the pipe connections, as shown in *Fig. 1*, the lower one being kept full of water, and the upper one of oil.

The following are some of the results of the test:

Date, January 19, 1889,	
Time of of test,	3 hrs. 10 m.
Temperature gas,	62°·2
Temperature of exhaust,	774°·28
Temperature of entering water,	50°·43
Temperature of exit water,	89°·19
Manometer, inches water,	3·06
Barometer (reduced to pounds),	14·85
Total gas used, cubic feet,	344·4
Gas for ignition,	9·625
Average revolutions per minute,	161·6
Explosions missed per minute,	6·83

COMPUTATION.

As the test was rather for determining the distribution of the head developed by burning the gas, or for getting data for determining its efficiency as a heat engine rather than as a machine, and as the observing force was limited, the brake horse-power was not taken.

The indicator cards were worked up in the following way. *Fig. 2* is a mean card obtained as follows: On each of the forty-two cards taken, twenty-eight lines were drawn at right angles to the atmospheric line as shown, and the pressure of the bottom and top of each card was read and tabulated. From the mean of these tabulated values, the card shown in the figure was drawn. From this card the horse-power was calculated as follows:

Mean pressure for card = 59 pounds.

Mean pressure per foot = 59 × 144 pounds.
Value of stroke in feet = ·2594.
Work per explosion = 59 × 144 × ·2594 ft. pounds.

$$\text{Explosion per minute} = \frac{161{\cdot}6}{2} - 6{\cdot}83 = 73{\cdot}97.$$

$$\text{Horse-power} = \frac{73{\cdot}97 \times 59 \times 144 \times {\cdot}2594}{33{,}000} = 4{\cdot}939.$$

It will be noticed that the exhaust and admission parts of the diagram are omitted as they practically coincided with the atmospheric line.

In addition to finding the work done, the mean card was used to determine the general equation of the expansion, compression and explosion part of the diagram.

In determining these curves the part between ordinates (8) and (28) was taken for the compression curve in the calculation; the explosion curve was taken to embrace all the upper curve between (23) and (28); and the expansion curve was taken to cover all the upper curves between (5) and (18).

The expansion and compression curves were assumed to vary according to a law $p v^n = c$, in which p is the pressure in pounds per square inch, and v = the volume in cubic feet of the mixture, while c and n are constants. By taking the values of p and v, as given on the mean indicator card by the method of Least Squares, the most probable values of n and c were determined.

The equation to the curve of expansion was found to be

$$p\, v^{1{\cdot}4385} = 15{\cdot}901$$

and for the compression curve was found to be—

$$p\, v^{1{\cdot}5313} = 3{\cdot}7557.$$

The explosion curve was found to be practically a parabola, whose equation is—

$$y = -1{\cdot}788\, x + 32{\cdot}833 \pm \sqrt{89{\cdot}423\, x - 1588{\cdot}61}$$

in which

$$y = \frac{p}{10},\ x = 100\, v.$$

The broken lines on *Fig. 2* show the curves corresponding

to the equation, and the following table gives the errors by calculation.

EXPANSION CURVE.

v	p from equation.	p from card.	v	p from equation.	p from card.
·23855	124·97	123.20	·32109	81·52	81·39
·25034	116·60	117·18	·33288	77·41	77·63
·26213	109·11	110·34	·34467	73·62	73·89
·27392	102·47	103·49	·35646	70·14	70·15
·28571	96·44	97·03	·36825	66·97	66·89
·29750	90·98	91·25	·38004	63·98	63·56
·30929	86·02	86·25	·39183	61·23	59·99

COMPRESSION CURVE.

v	p from equation.	p from card.	v	p from equation.	p from card.
·17960	52·06	52·25	·25034	31·32	31·41
·18550	49·55	49·13	·26213	29·19	29·25
·19139	47·24	47·08	·27392	27·29	27·30
·19729	45·09	44·87	·28571	25·58	25·53
·20318	43·10	42·91	·29750	24·04	23·91
·20908	41·26	41·27	·30929	22·65	22·72
·21497	39·54	39·60	·32109	21·39	21·46
·22089	37·93	38·32	·33288	20·24	20·34
·22676	36·43	36·94	·34467	19·19	19·15
·23266	35·03	35·39	·35646	18·22	18·34
·23855	33·70	33·94			

EXPLOSION CURVE.

v	p from equation.	p from card.	v	p from equation.	p from card.
·1796	48·90	51·25	·19729	108·70	108·70
·1855	80·59	81·01	·20318	116·55	116·99
·19139	97·10	97·01	·20908	121·91	122·49

HEAT.

From the mean indicator card it was found that the mean pressure was fifty-nine pounds per square inch, and the work performed per explosion was $59 \times 144 \times ·2594$ (volume passed through by the piston) $= 2203·8$ foot pounds. This is equivalent to—

$$\frac{2203·8}{772} = 2·854$$

heat units transformed into work at each explosion.

From the amount and temperature of the jacket water it was found that 461·92 heat units were carried away per

minute by the cooling water. Or as there were 73·97 explosions per minute—

$$\frac{461{\cdot}92}{73{\cdot}97} = 6{\cdot}24$$

heat units removed per explosion by the cooling water.

The following gives the results of the tests of the gas used as determined by the Elliott apparatus:

	By Volume. Per Cent.	*By Weight. Per Cent.*
CO_2,	·50	1·923
C_2H_4,	4·32	10·520
O,	1·00	2·797
CO,	6·33	15·419
CH_4,	27·18	38·042
H,	51·57	9·021
N,	9·06	22·273

The following are the calculated results from these values:

	Weight per Explosion.	*Heat Developed per Explosion.*	*Oxygen Required.*	*Products of Combustion. H_2O*	*CO_2*
CO_2,	·00001210	—	—	—	—
C_2H_4,	·00013903	1·6785	·00045667	—	·00001210
O,	·00002420	—	·00002420	·00017852	·00043682
CO,	·00011313	·5322	·00006464	—	·00017776
CH_4,	·00027730	6·4927	·00110920	·00062396	·00076260
H,	·00006580	3·7364	·00052640	·00059216	—
N,	·00016190	—	—	—	—
	·00079346	12·4398	·00213271	·00139464	·00138928

Nitrogen,	·007101
Air required,	·00923373
Gas,	·00079346
Total water gas and air entering cylinder per explosion,	·01003319

H_2O,	·00139464
N added,	·00710110
N,	·00016190
	·01005594

The heat carried off in the products of combustion is—

	Heat Units.		*Per Cent.*
In H_2O (steam),	1·9291		
CO_2,	·2149		
N,	·2438		
Heat carried off in exhaust,	3·4049	$= \frac{3{\cdot}40}{12{\cdot}44}$	= 27·93
Heat converted into work,	= 2·85		= 22·91
Heat taken by jacket water,	= 6·24		= 50·16
Total heat accounted for,	= 12·49		100·4
Total heat received,	= 12·44		

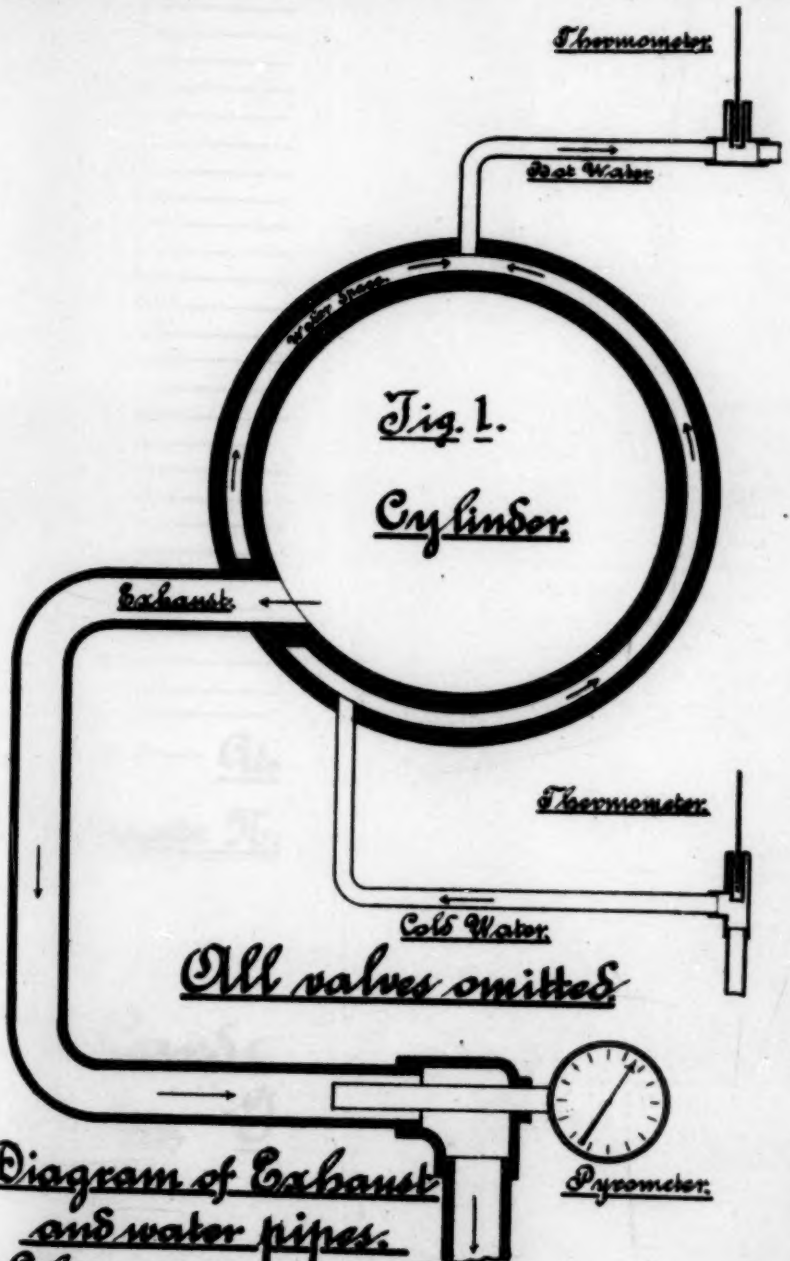
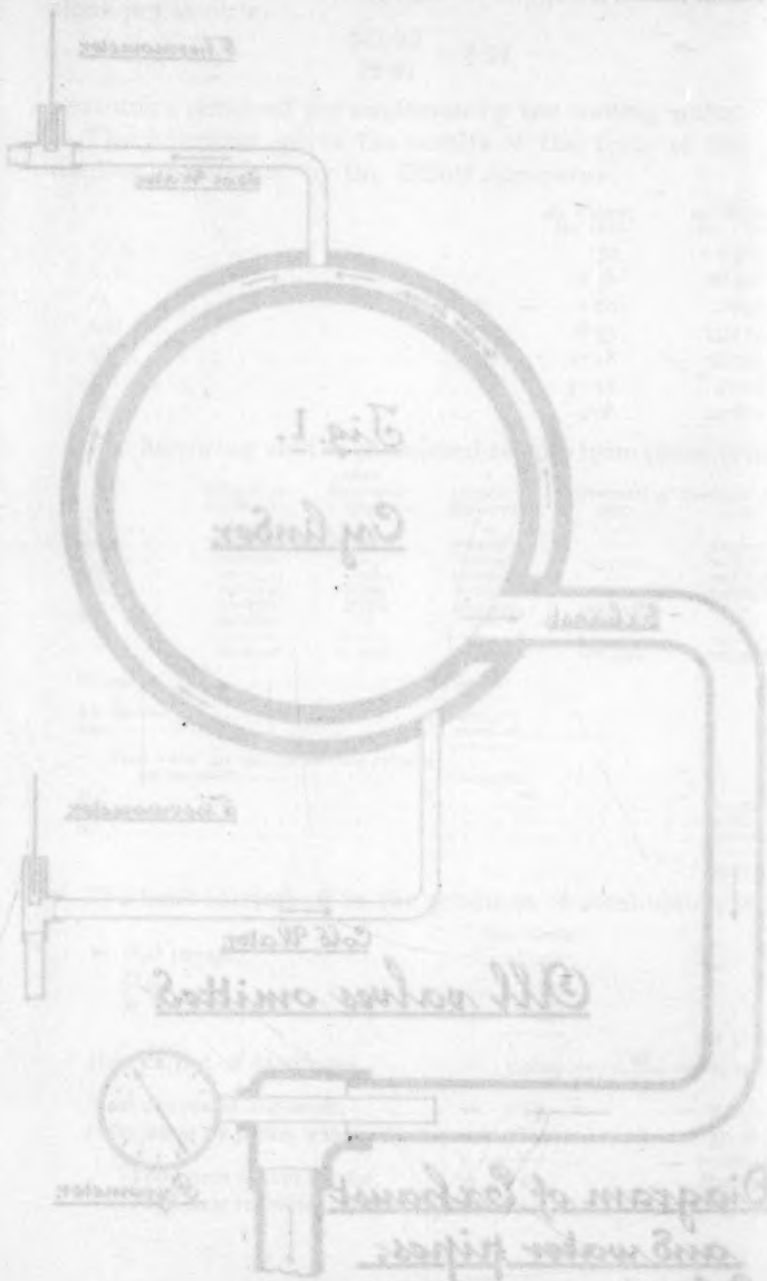


Fig. 1.

Cylinder.

Diagram of Exhaust and water pipes. Showing connections for Thermometers and Pyrometer.



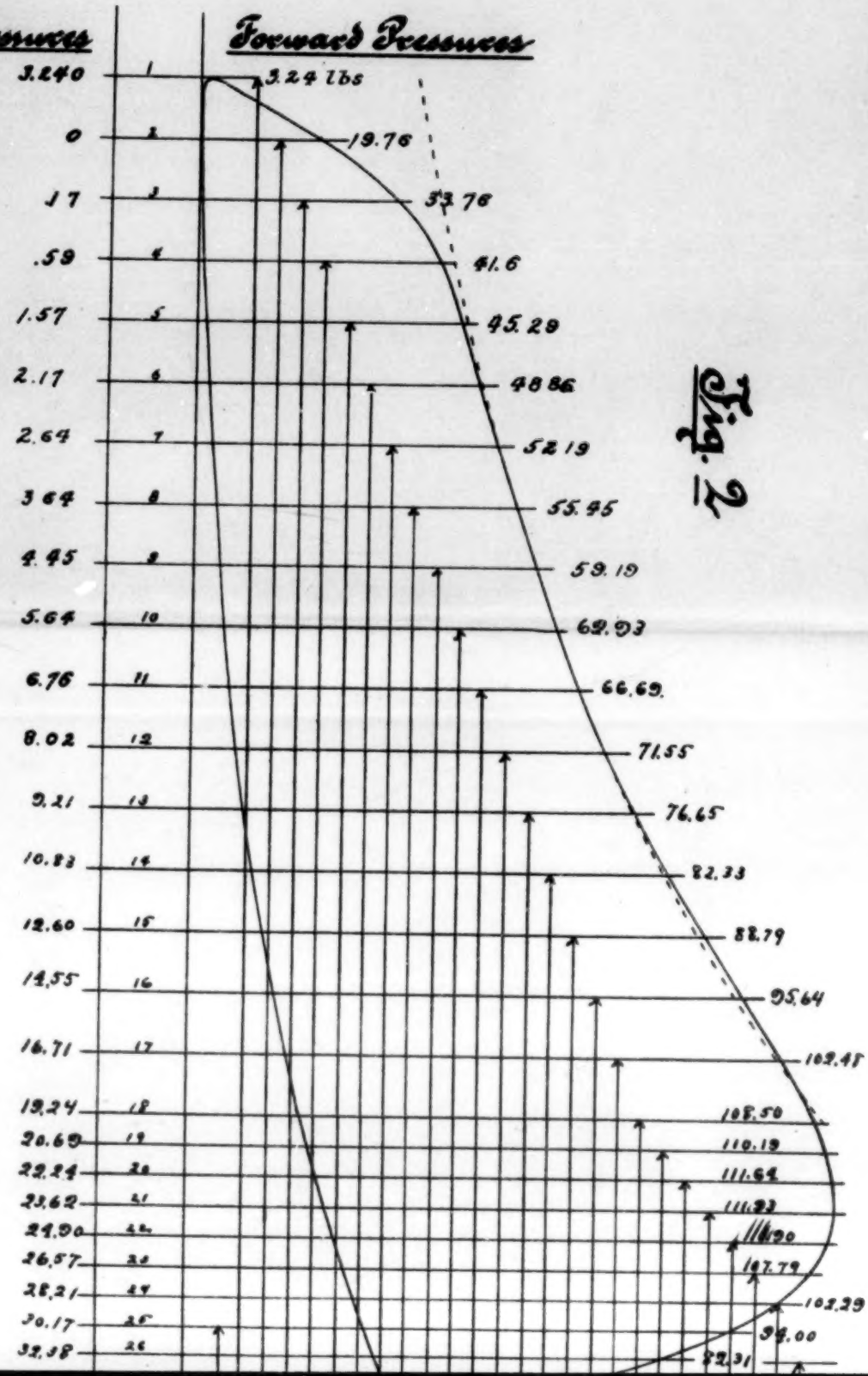
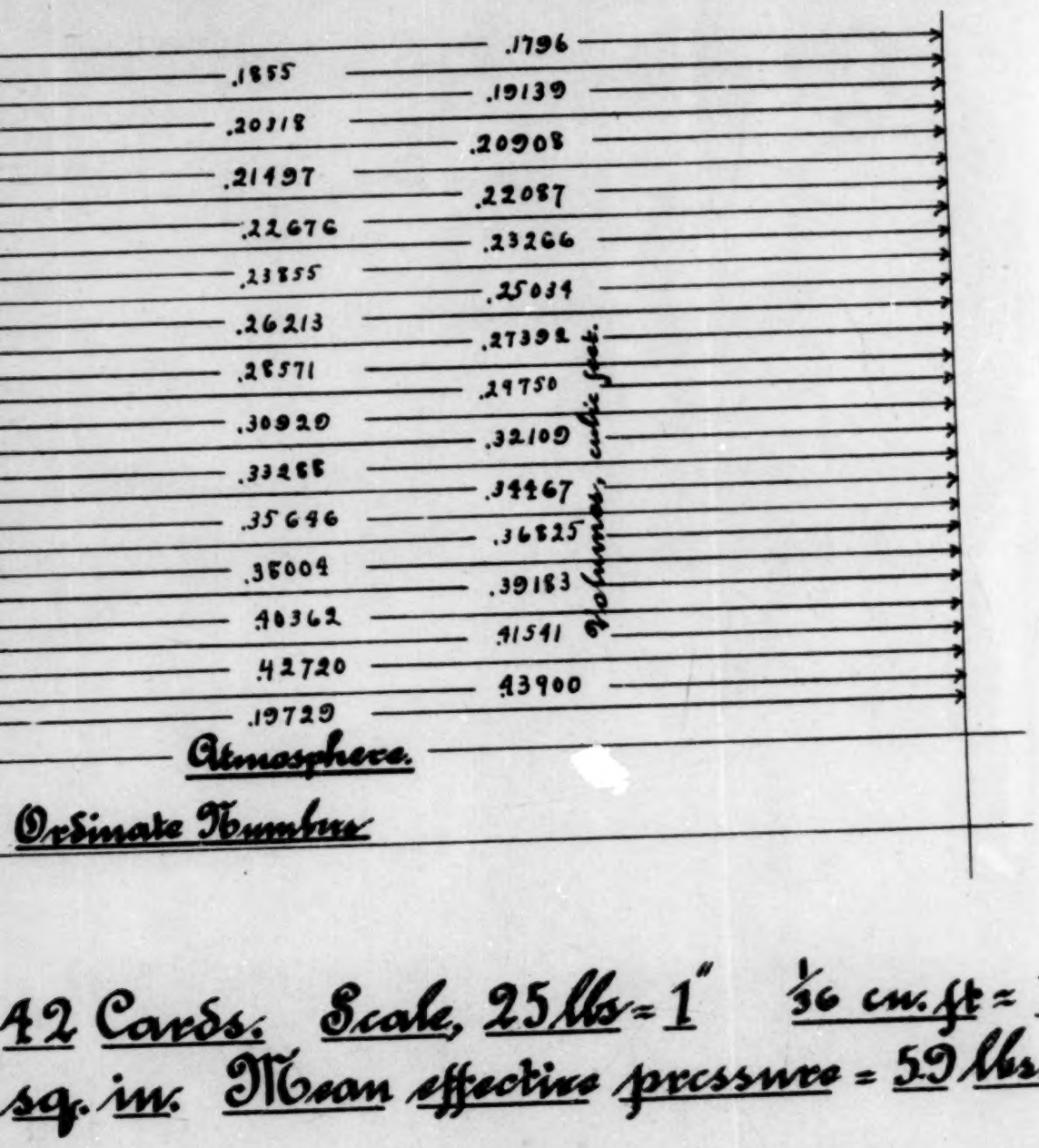


Fig. 2

Indicator Diagram of Otto Gas Engine. Mean Pressure 19.76 lbs. Speed 161.6 Revolutions per minute. Area cards = 2

Ordin

Otto Gas Engine. Mean of 42 C
per minute. Area card = 22 sq.



42 Cards. Scale, 25 lbs = 1" 1/36 cu. ft = 1"
sq. in. Mean effective pressure = 59 lbs.

These calculations are made on the supposition that the amount of air supplied to the cylinder is just enough to cause complete combustion, and are given for what they are worth. That they are, at least to a certain extent, justifiable can be seen from the following:

·00079346 pounds of gas occupying

$$\frac{334{\cdot}78 \text{ (cubic feet, total)}}{14054 \text{ (no. explosion)}} \text{ cubic feet}$$

at 62°·2 F. and a pressure of 14·96 pounds per square inch, requires ·00923373 pounds of air to completely burn it.

It is fair to suppose that just before the mixture of gas and air is compressed it has the temperature of the cylinder, which must be about that of the jacket water or 89°·19 F. The gas occupies a volume of

$$\frac{334{\cdot}78}{14054} \times \frac{548{\cdot}59}{521{\cdot}6} \times \frac{14{\cdot}96}{14{\cdot}85} = {\cdot}02523 \text{ cubic feet.}$$

·00923373 pounds of air at 14·85 pounds per square inch and a temperature of 89·19 occupies ·22985 cubic feet. The total volume occupied by the gas and air is therefore ·25508 cubic feet. The clearance volume was filled with the products of combustion at this same pressure and temperature before the mixture of gas and air was drawn in. The incoming gas and air should therefore fill a volume equal to the stroke displacement, or ·2594 cubic feet, and we have therefore a volume of air = ·2594 — ·25508 = ·00432 cubic feet of air drawn in, but not used, a quantity that we can omit in our calculations.

PHILOSOPHY OF THE MULTI-CYLINDER, OR COMPOUND, ENGINE; ITS THEORY AND ITS LIMITATIONS.*

By Robert H. Thurston, Ithaca, N. Y.

[*Concluded from vol. cxxix, p. 68.*]

The following are illustrations of approximate solutions of such problems; as arising in common practice or as illustrated in the experiences of the engineer seeking to ascertain which of all available designs is the best for the special purposes in view:

First, referring to the methods of computation employed by Rankine,† we find there, perhaps, the simplest and most convenient systems of treatment of the ideal case. Taking a series of values of initial pressure and of corresponding ratios of expansion, he computes the efficiencies of fluid and tabulates the results in a very compendious form. Accepting these figures, which have been checked by the writer, we have the following:

* Presented at the Twentieth Meeting of the American Society of Mechanical Engineers, held in New York, November, 1889. Revised by the author for publication in the Journal, and printed by permission from advance sheets of the Society's *Transactions*.

† *Manual of the Steam-Engine*, pp. 410, 411.

Condensing Steam-Engines With Dry Saturated Steam.

Back pressure $p_2 \div 144$, assumed at 4 lbs. on the square inch.

Examples.	Ratio of Expansion, r, and Effective Cut-Off, $\frac{1}{r}$.							
	10'	5'	3'33	2'5	2'	1'7	1'25	1'
	0'1	0'2	0'3	0'4	0'5	0'6	0'8	1'0
(1) $p_1 \div 144 = 20$.								
$(p_m - p_2) \div 144$,	. . .	. .	8·8	11 1	12·8	14·0	15'5	16 0
$p_2 \div 144$,	. . .	. . .	93	124	155	186	248	310
Efficiency of steam,	. . .	. . .	·095	·090	·083	·075	·0625	·052
(2) $p_1 \div 144 = 40$.								
$(p_m - p_2) \div 144$,	. . .	16·2	21·9	26·2	29·6	32·0	35·0	36·0
$p_2 \div 144$,	. . .	124	186	248	310	372	496	620
Efficiency of steam,	. . .	·131	·118	·118	·095	·086	·071	·058
(3) $p_1 \div 144 = 60$.								
$(p_m - p_2) \div 144$,	14·8	26·3	34·9	41·4	46·4	50·0	54·6	56·0
$p_2 \div 144$,	93	186	279	372	465	558	744	930
Efficiency of steam,	·159	·140	·125	·111	·100	·090	·073	·060
(4) $p_1 \div 144 = 80$.								
$(p_m - p_2) \div 144$,	21·1	36·4	47·8	56·5	63·2	68·0	74·1	76·0
$p_2 \div 144$,	124	248	372	496	620	744	992	1240
Efficiency of steam,	·170	·147	·128	·114	·102	·091	·074	·061
(5) $p_1 \div 144 = 100$.								
$(p_m - p_2) \div 144$,	27·4	46·5	60·8	71·6	80·0	86·0	93·6	96·0
$p_2 \div 144$,	155	310	465	620	775	930	1240	1550
Efficiency of steam,	·177	·150	·131	·115	·103	·092	·075	·062

Non-Condensing Steam-Engines With Dry Saturated Steam.

Back pressure $p_2 \div 144$, assumed at 18 lbs. on the square inch.

Examples.	Ratio of Expansion, r, and Effective Cut-Off, $\frac{1}{r}$.						
	5'	3'53	2'5	2'0	1'7	1'25	1'0
	0'2	0'3	0'4	0'5	0'6	0'8	1'0
(6) $p_1 \div 144 = 60$.							
$(p_m - p_2) \div 144$,	. . .	. . .	27'4	32'4	36'0	40'6	42'0
$p_2 \div 144$,	. . .	. . .	372	465	558	744	930
Efficiency of steam,	. . .	. . .	·074	·070	·064	·055	·045
(7) $p_1 \div 144 = 80$.							
$(p_m - p_2) \div 144$,	. . .	33'8	42'5	49'2	54'0	60'1	62'0
$p_2 \div 144$,	. . .	372	496	620	744	992	1240
Efficiency of steam,	. . .	·091	·086	·080	·073	·061	·050
(8) $p_1 \div 144 = 100$.							
$(p_m - p_2) \div 144$,	32'5	46'8	57'6	66'0	72'0	79'6	82'0
$p_2 \div 144$,	310	465	620	775	930	1240	1550
Efficiency of steam,	·105	·100	·093	·085	·077	·064	·053
(9) $p_1 \div 144 = 120$.							
$(p_m - p_2) \div 144$,	42·6	59·8	72·8	82·8	90 0	99'2	102·0
$p_2 \div 144$,	372	558	744	930	1116	1488	1860
Efficiency of steam,	·115	·107	·098	·089	·081	·067	·055
(10) $p_1 \div 144 = 160$.							
$(p_m - p_2) \div 144$,	62·8	85·6	103·0	116·4	126·0	138·2	142·0
$p_2 \div 144$,	496	748	992	1240	1488	1984	2480
Efficiency of steam,	·127	·115	·104	·094	·085	·070	·057

Taking the temperature of feed-water at such a point as will give for each case nine pounds of water evaporated into dry steam per pound of fuel, and 2·5 pounds of steam per horse-power per hour at efficiency unity, it is easy to make a comparison of the probable ideal and the probable actual efficiencies of these various engines in terms of heat, steam, and fuel, demanded per unit of power in the unit of time. Rankine, in his computation as presented in the original tables, assumes an evaporation of but 7·24 per unit weight of fuel; but this is far too low to represent contemporary good practice. He also omits all correction for wastes, the two quantities to a certain extent balancing and often giving his final results in fuel consumed more nearly usual actual values than they would otherwise have exhibited. The following are selected illustrations of common practice at the several pressures and ratio of expansion given:

IDEAL EFFICIENCIES OF ENGINE.

CASE NO.	$p_1 \div 144$.	r	E	WEIGHT (PER I. H. P. PER HOUR) POUNDS.	
				Steam.	Fuel.
1,	20	2	0·083	30·11	3·35
2,	40	2·5	0·106	23·58	2·62
3,	60	3·3	0·125	20·00	2·22
4,	80	4·0	0·130	19·62	2·18
5,	100	5·0	0·150	16·67	1·85
6,	60	2·5	0·074	33·78	3·75
7,	80	3·33	0·091	27·78	3·09
8,	100	5·0	0·105	23·81	2·65
9,	120	5·0	0·115	21·74	2·42
10,	160	5·0	0·127	18·90	2·10

Thus much for the ideal case in which the steam is either worked in a non-conducting cylinder or in an otherwise perfect engine, the steam being kept in the dry and saturated state by adding heat during expansion in just the quantity needed to prevent its partial condensation in consequence of the conversion of its heat into work. Adding to the above computed quantities of steam and of fuel those demanded to supply the wastes invariably met with in greater or less amount in all actual engines, we may obtain figures of probable approximate, perhaps closely approxi-

mate, values, for real work in the every-day practice of good engineering.

To determine the probable real efficiency of fluid, allowing for transfer without transformation, by internal wastes other than thermodynamic, assume the engines to be of moderate size and operated under familiar conditions, such as those which were met with in the experiments conducted under the system planned by the writer, by Messrs. Gately and Kletsch, in which the wastes were very exactly measured by the expression $c = 0{\cdot}2 \sqrt{r}$, for the non-condensing unjacketed engine, and take the losses of the jacketed engine at a common proportion, three-fourths that amount, $c = 0{\cdot}15 \sqrt{r}$. Adding this proportion to the previously computed amounts for the ideal case, we obtain for the actual engine figures consonant, at least more consonant, with experience. Further, assume that it is practicable, in each case, to make the mechanical efficiency of the non-condensing machine 0·90 and the condensing engine 0·85, usual figures for the two classes. Then we obtain the following for indicated and for dynamometric power:

ACTUAL EFFICIENCIES OF ENGINE.

CASE NO.	$p_1 + 14.$	r	E	STEAM.		FUEL.	
				I. H. P.	D. H. P.	I. H. P.	D. H. P.
1, ...	20	2	0·069	36·2	42·6	4·0	4·7
2, ...	40	2·5	0·085	29·2	34·4	3·2	3·8
3, ...	60	3·3	0·092	25·5	30·0	2·8	3·3
4, ...	80	4·0	0·100	23·0	29·2	2·8	3·2
5, ...	100	5·0	0·109	22·9	26·9	2·5	3·0
6, ...	60	2·5	0·050	44·9	50·9	5·0	5·5
7, ...	80	3·3	0·067	37·0	40·1	4·1	4·5
8, ...	100	5·0	0·073	34·2	38·0	3·8	4·2
9, ...	120	5·0	0·080	31·3	34·8	3·5	3·9
10, ...	160	5·0	0·087	28·7	32·0	3·2	3·6

Drier or superheated steam, higher piston-speed, larger powers of engine, efficient jacketing, will increase these efficiencies by reducing wastes; the opposite conditions will decrease them. The figures have been taken as representing fairly good practice in construction for the conditions of thermodynamic operation assumed by Rankine. Condens-

ing engines are found to promise about twenty per cent. better performance than non-condensing, a promise fulfilled in good practice.

The differences between the steam-consumption figures of the two tables represent those wastes which may be largely reduced by compounding; they amount to a nearly constant quantity, six pounds of steam for the condensing and ten pounds for the non-condensing engines. A two-cylinder compound engine should reduce these wastes to approximately three and five pounds, a triple-expansion to two and to 3·3 pounds, a four-cylinder quadruple-expansion engine to 1·5 and to 2·5. The latter, however, with such pressures as are here assumed for the condensing engine, would unquestionably exaggerate other wastes and costs so as to, on the whole, prove unadvisable. Case No. 5, using 23 pounds of steam per hour per horse-power, would, as a compound engine, demand 20 pounds, as a triple-expansion, 19 pounds, and as a quadruple-expansion engine about 18·2.

All these cases, however, fail to represent modern practice; since they do not assume a sufficient expansion to give best results when compounded. The benefits of the multi-cylinder type are best seen with extreme ratios of expansion, when the internal wastes would prove excessive in the simple engine.

As a better illustration of recent and advanced practice, a quadruple-expansion is to be compared with a triple-expansion engine at a pressure of 200 pounds per square inch, absolute, with a back-pressure of 8 pounds and a total ratio of expansion of 16, or of $2{\cdot}5^3$ in the one case and of 2^4 in the other. The condenser is worked at a temperature of 150° F., in both cases, the feed being at 145° F. The friction of engine is taken in both at 15 per cent., the efficiency of machine being 0·85. The boiler evaporates nine pounds of water per pound of coal. The engines are jacketed efficiently, and the waste is taken to be measured by the factor $c = 0{\cdot}15\sqrt[3]{r}$, $= 0{\cdot}15\sqrt[3]{2{\cdot}5}$ for the one case and $c = 0{\cdot}15\sqrt[4]{2}$ in the other, or 24 and 21 per cent. for the three and the four-cylinder engines, respectively. For a single engine, it would be $c = 0{\cdot}15\sqrt{16} = 60$ per cent.

Adopting Rankine's method and formulas, we obtain the following results:

For the ideal case, which would give nearly the same figures for both engines, we find the following, the slight discrepancies being due to the corresponding difference in total expansion, taking the one to work at a ratio of 2·5 for each cylinder, and the other at 2:

IDEAL MULTI-CYLINDER ENGINE EFFICIENCIES.

ENGINE.	No. CYLINDER.	E.	B. T. U. PER I. H. P.	WATER PER I. H. P.	COAL PER I. H. P.
Triple,	1	·0811			
	2	·0730			
	3	·0779			
Total,		·231	11761	10·85	1·35
Quadruple,	1	·0637			
	2	·0508			
	3	·0580			
	4	·0598			
Total,		·2414	11577	10·68	1·34

The consumption of water and of fuel is thus extremely low, as compared with the actual performance of the preceding cases. Adding the allowances for internal wastes, we have:

EFFICIENCIES OF REAL ENGINE.

ENGINE.	WATER PER I. H. P.	COAL PER I. H. P.
Ideal,	10·8	1·2
Simple,	17·3	1·9
Triple,	13·4	1·5
Quadruple,	13·1	1·4

Had these engines been unjacketed, we might probably have obtained the following by multiplying the ideal figure by $1 + c = 1 + 0{\cdot}2\sqrt{r}$:

UNJACKETED ENGINES.

ENGINE.	WATER PER I. H. P.	COAL PER I. H. P.
Ideal,	10·8	1·2
Simple,	19·4	2·2
Triple,	14·3	1·6
Quadruple,	13·8	1·5

The gain by increasing complication thus decreases as

the number of cylinders increases, whatever the rate of internal waste.

Going into higher and unaccustomed pressures, it may be interesting to endeavor to compute the probable performance of a well designed quintuple-expansion engine, working at a pressure of 500 pounds per square inch. The ratio of expansion is taken at $r = 2{\cdot}3^5 = 64{\cdot}4$, the back-pressure at five pounds. Adopting Rankine's approximate formulas, we obtain:

QUINTUPLE-EXPANSION ENGINE.

Data:

$p_1 = 500 \times 144 = 72{,}000$ lbs. per sq. ft.

$p_3 = 5 \times 144 = 720.$

$r = 2{\cdot}3^5 = 64{\cdot}4.$

Results:

$p_2 = 862{\cdot}2$ lbs. per sq. ft., 6 lbs. per sq. in.

Heat expended per lb., $H = 27{,}324$ ft. lbs. $= 1{,}898$ *B.T.U.*

$p_e = \frac{H}{V_2} = 4{,}464$ lbs. per sq. ft., 31 lbs. per sq. in.

$p_h = 17{,}330$ lbs. per sq. ft., $120{\cdot}3$ lbs. per sq. in.

Efficiency of fluid, $E = \frac{p_e}{p_h} = 0{\cdot}2576.$

B. T. U. per *I. H. P.* per hr. $= 10{,}189.$

Steam per *I. H. P.* per hr., at 1,100 units per lb., $= 9{\cdot}32$ lbs.

Coal per *I. H. P.* per hr. at 9 lbs. evap. $= 1{\cdot}03$; say 1 lb.

For this case, therefore, the weights of steam and of fuel, for unity efficiency, would be approximately $2{\cdot}4$ pounds, and about $0{\cdot}3$ pound per horse-power per hour. Were the internal wastes to be taken as in the first part of this paper, as indicated by the experiments there referred to, we should have the following, assuming the losses to be reduced in proportion to the number of cylinders employed, and the efficiency of mechanism to be $0{\cdot}95$ for the simple engine; $0{\cdot}90$, $0{\cdot}90$, $0{\cdot}85$ and $0{\cdot}85$ for the compounded engine in the five cases given, respectively:

EFFICIENCIES OF MULTI-CYLINDER ENGINES.

ENGINE.	WATER PER I. H. P.	FUEL PER I. H. P.	E E.	WATER PER D. H. P.	FUEL PER D. H. P.
	Pounds.	Pounds.		Pounds.	Pounds.
Ideal Engine,	9·32	1·	1	9·32	1·
Simple jacketed,	20·5	2·2	95	21·4	2·4
Double expansion,	14·9	1·6	90	16·5	1·8
Triple expansion,	13·0	1·4	90	14·4	1·6
Quadruple expansion,	12·1	1·34	85	15·0	1·7
Quintuple expansion,	11·6	1·24	83	13·6	1·5

The above is sufficient to give a fair idea, assuming our figures are satisfactorily approximate for the as yet unexplored regions to which they refer, of the advances to be anticipated by the engineer through the use of higher pressures and ratios of expansion, and with saturated steam. These figures may be decreased indefinitely by increasing boiler efficiency and by superheating the steam.

The influence of size of engine may be important. In all of the examples taken, it has been assumed that the engines were of considerable size and of moderate speed of piston; at least, such that the rate of condensation found by experiment might be fairly assumed to apply to them. It will now be interesting to endeavor to obtain some idea of the effect of variation of size of engine upon their performance. That this is not necessarily serious, with even quite small engines, when proper precautions are taken to make the waste a minimum, is seen in the results of the trials of agricultural engines at the British Society "Shows," where engines of ten and twenty horse-power are exhibited, giving as high efficiency as the average of fairly good engines of the same working pressures at sea, both simple and compound being compared. But it is evident that the greater extent of surface exposed, per unit weight of working fluid subject to condensation, must, other circumstances being equal, give the larger engine the advantage.

To make this comparison, it is necessary to ascertain the waste per unit area of surface exposed, per unit of time of exposure and per unit range of temperature within the cylinder. The experiments of Messrs. Gately and Kletsch, as

shown by Professor Marks,* give for this quantity, assuming it for present purposes a constant, a value never far from $c = 0{\cdot}02047$, which is here taken as the value affecting the cases assumed. Let the data be as follows:

INFLUENCE OF SIZE.

Data:

Engine single-acting compound.
Clearance, 20 per cent.
Boiler pressure, 165 lbs. per sq. in., 23,660 per sq. ft.
Back pressure, 18 lbs. per in., 2,592 per sq. ft.
Ratio of expansion in *H. P.* cylinder, 2·5.
Ratio of low to high pressure cylinder, 2·78 to 1.
Piston speed, 600 feet per minute.
Initial volume, v_1, 2·8 feet; final, v_2, 7 feet; $p_2 = 8{,}690$.

Results.

Weight of steam in low pressure clearance, 0·554 lbs.
Compression begins at 0·047; *M. E. P.*, in *H. P.* cylinder 6,400 lbs.
Ditto in *L. P.* cylinder, 1,940 lbs. per ft.
Weight of steam in *L. P.* cylinder, 1·054 lbs.
Energy of steam per lb., 138,860 ft. lbs.
Efficiency of the steam, $E = 0{\cdot}1413$.
Water per *H. P.* per hour, lbs., 17·56.
Fuel at 10 lbs., per lb., 1·76.
Heat, at usual equivalent, per I.H.P. per hour, 19,766 *B.T.U.*

The above figures show what the ideal engine would do under the given conditions and what would be the performance of the real engine, irrespective of size, were there no wastes. With varying sizes, the volumes v, worked at any given ratio of expansion, the stroke of piston being made variable with the diameter of the cylinder, will vary as the cubes of the diameters; while the surfaces, s, exposed will vary as the squares. The wastes occurring internally will thus vary as the quantity $s \div v$, or inversely as the diameter with cylinders of similar proportions. If the stroke be kept unchanged, the diameters varying, the wastes will vary as above, with the variations of surfaces

* *Proportions of Steam Engine.* 3d Ed. p. 257.

and volumes, but less rapidly than in the first case with a given variation of power. In illustration, take three engines of the assumed type, having dimensions as below:

(1) 18″ and 30″ × 16″ stroke.
(2) 9″ and 15″ × 9″.
(3) 3″ and 5″ × 3″.

Taking the internal wastes, as already proposed, and using the coefficient $c = 0{\cdot}02047$, and computing the loss on the areas of the piston, the clearance, and port passages and interior of cylinder up to point of cut-off, we obtain the following results:

VARIATION OF EFFICIENCY WITH SIZE OF ENGINE.

ENGINE.	AREAS.	I.H.P.	FUEL AND WATER PER H.P.		CONDEN. PER I.H.P.	FRIC.
			I.H.P.	D.H.P.		
Ideal			17·6 ; 17·6			
No. 1	10·16	220·7	23 ; 23	27 ; 27·0	5·4	15 p.c.
" 2	2·65	30·37	28 ; 27·9	36 ; 36·1	10·30	20 p.c.
" 3	0·294	1·132	48 ; 48·25	67 ; 67·33	30·7	25 p.c.

The enormous effect of this method of waste in small engines, and the very considerable influence of size upon its magnitude in the smaller classes of engines, are thus well exhibited. It is here seen that compounding is a very much more effective means of economizing in the expenditure of fuel and of steam in small than in large engines, a remark which probably applies to all methods of increasing efficiency by reducing these once mysterious kinds of loss. In the above instance, the interior wastes increase from 5·4 pounds to 10 and to 30 pounds per I. H. P., as size decreases, and the consumption of steam thus rises from 17·6 in the ideal case, to 28 and 48 pounds for the smaller engines.

As a final illustration of the methods of treatment of the multi-cylinder engine here exhibited, an example will be selected from practice, taking an engine which is representative of the earliest attempts to employ very high steam pressures in a triple-expansion engine. The steamer *Anthracite*, built by the Messrs. Perkins, is a small vessel having triple-expansion engines, and boilers constructed to

safely bear very high pressures. During the working and the special trials of the ship, the pressures were carried between 350 and 400 pounds by gauge; but the pressures in the cylinders fell very much below these figures. The following are data fairly representing one of the trials of this vessel, and the ideal case is worked out from them as below:

TRIPLE-EXPANSION ENGINES.

Data:

$$p_1 = 201{\cdot}64;\ p_2 = 9{\cdot}55;\ p_3 = 4{\cdot}21.$$
$$T_1 = 843{\cdot}47;\ T_2 = 652{\cdot}2;\ T_3 = 120{\cdot}5.$$
$$v_1 = 2{\cdot}236;\ v_2 = 57{\cdot}49;\ r = 25{\cdot}71.$$

Results (ideal):

$E = 0{\cdot}227$; $p_2 = 3929{\cdot}15$ per sq. ft. = 27 28 per sq. in.

Feed-water per I. H. P. per hour = 8.3 pounds.

The efficiency of the boilers was, by test, 0·68, and the consumption of steam per I. H. P. per hour, assuming it to be of such quality as would, with unity efficiency, give an evaporation of 11·75 to 1, would be, per I. H. P.:

$$8{\cdot}3 \div 11{\cdot}75 \div 0{\cdot}68 = 0{\cdot}92 \text{ lbs.}$$

The best work done on reported trials, as stated by Sir Frederick Bramwell, and as recomputed by the United States Naval Board repeating the trials, was 17·8 pounds of feed-water, 1·7 pounds of coal, and 20,022 B. T. U. per indicated horse-power per hour, the steam being presumed to be, as above taken, dry and saturated, the jackets working efficiently. The total ratio of expansion was 25·7, in the first cylinder 2, and in the last 3·5. The waste was thus slightly more than equal to the thermodynamic demand for steam, and 50 per cent. of the total supplied. This would correspond to $c = 0{\cdot}2\sqrt{r}$ for the simple engine, and to more nearly $c = 0{\cdot}6\sqrt{r}$ for the single cylinder of maximum ratio of expansion. The conclusion is thus at once reached that this engine, economical as it was for its time, was not nearly as efficient as it should have been, in consequence of its wastes having been so great as to obscure the gain which should have been secured by the expansion to such a degree of such high steam. In fact, its wastes were as

great as they would have probably been in a simple engine with unjacketed cylinders, working at moderately high piston-speed. Had its superheating tubes worked with satisfactory effect, it should have been possible to reduce the expenditure of feed-water and of fuel, to as little as has been given for a similar case in the earlier part of this paper. The losses should have been not more than one-third those actually experienced, and the consumption should not have exceeded 11 or 12 pounds of water and 1·3 pounds of fuel.

How far the actual wastes were due to other methods of exaggeration of loss, as by external conduction and radiation, and by internal leakage, it is impossible to say. These may account for much of the discrepancy. Whatever the true cause, it is easy to see that a comparison of the ideal with the real case, as above illustrated, would always exhibit the fact of the waste and its amount, and enable the engineer to trace out the causes and to remedy them, either in the operation of the engine considered, or in subsequent designs, where the fault is inherent in the type or special construction.

Problems relating to the efficiency of the multi-cylinder engines may be solved most simply by the processes devised by the writer in modification of the method of Rankine, originally applied to the study of the ratio of expansion at highest efficiency of capital.* The number of cylinder or of grades of expansion being in all such cases settled by general experience and the judgment of the designing engineer, the best ratio of expansion and the best proportions of cylinders are readily determined for any given case by first obtaining the true curve of efficiency for the given class of engines, and then, knowing the probable back-pressure to be met with, either by custom or by taking it with reference to the best relation of initial to final pressure, and computing the constant and variable costs of operation, solving the problems, in their proper order, by a graphical construction which the writer has shown to be easily and accurately

* Miscellaneous Papers.

made.* It is enough to say here that these best ratios will often be found, for the better class of engines employing dry or slightly moist steam, to be not far from one-half the ratio of initial to back-pressure, the latter including the friction of engine; and for those of the very highest class, using thoroughly dry or superheated and reheated steam, on the system adopted by Cowper, Corliss and Leavitt, this best ratio may be raised economically, on the whole, to about two-thirds the ratio of initial to back-pressure. A good tentative rule is thus: *to obtain the total ratio of expansion.*

Rule.— Divide the initial-pressure in the high-pressure cylinder by twice the sum of back-pressure on the low-pressure cylinder, plus the friction of engine per unit area of piston, and the quotient will be approximately the best ratio of expansion for an average case. For the most economical classes of multi-cylinder engines, take, for the divisor, three-halves the back-pressure plus friction.

It is safer, however, to endeavor to find the real curve of efficiency for the class of engine considered, and use that curve in the solution of the problems of the efficiency of fluid, of efficiency of engine, and of efficiency of plant. It thus becomes easy to ascertain the best ratios for highest duty, for best financial results as designed, as for best commercial returns should the opportunity offer of utilizing more power than is at first anticipated.

Proportions of cylinders and relative ratios of expansion in the several cylinders of the multi-cylinder engine may readily be settled when the total ratio and the total power demanded are determined and exactly prescribed. It will be found that the total ratio will be made, usually, not far from equality in the several cylinders, and

$$r = r_1^n;$$

where n is the number of cylinders adopted, r the total ratio, and r_1 the best ratio for one cylinder. It will, however, for best effect, on the whole, be probably advisable to adopt a compromise between the various modified and conflicting

* "The Several Efficiencies of the Steam Engine." JOURN. FRANKLIN INSTITUTE, May, 1882.

values prescribed by the conditions that the work, the effective initial pressures, and the several differences of temperature, shall be as nearly equal in all cylinders as possible. To meet the first condition we must have such a ratio in each cylinder as shall make the work in each equal to the total net power of the engine divided by the number of cylinders in series; to meet the second condition we must make the initial pressure in each such that the total range of pressure may be equal to a common range in each multiplied by the number of cylinders; while to make the range of temperature equal throughout the series, we must have varying differences of pressure, the high-pressure cylinder having the maximum range, and the low-pressure cylinder the minimum range of pressure. The differences in this latter respect are, in engines using very high steam-pressure, quite considerable. Where the steam is dry, the speed of engine high, and the jacketing effective, this is a matter of less consequence than approximately uniform division of work and stresses on the crank-pins.

NEW YORK CITY AQUEDUCT: ITS ENGINEERING FEATURES AND DESIGN.

ALEX. CRAWFORD CHENOWETH,
Engineer in Charge, Croton Aqueduct.

[*A Paper read at the Stated Meeting, held October 16, 1889.*]

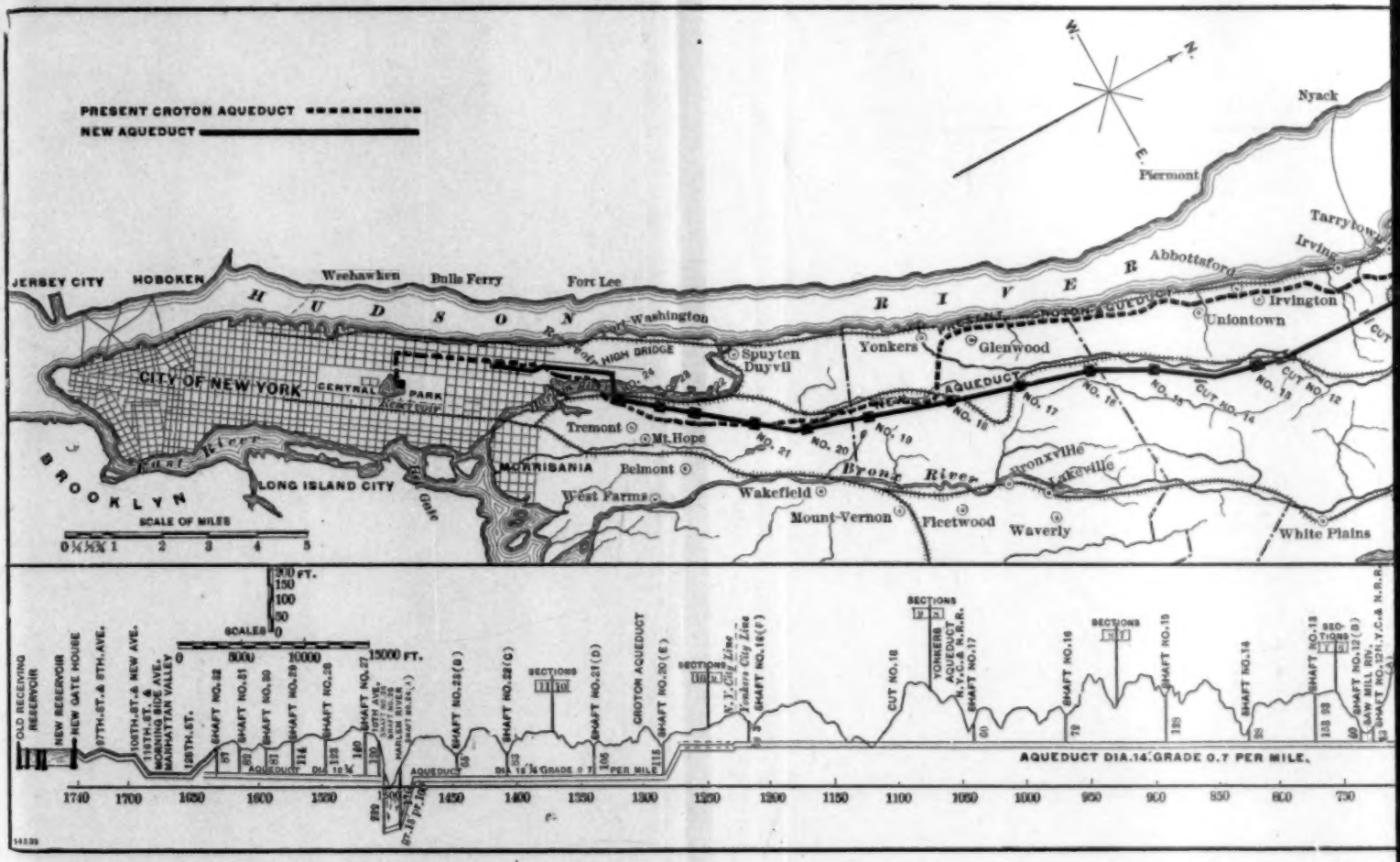
The opinion of engineers and others who have given the subject of additional water supply to the City of New York their attention and study, and their selection of the Croton River and water-shed has been well founded upon numerous investigations. The consideration of other sources, with a supposition that the Croton could not be relied upon, to furnish enough water for immediate demands, was under serious discussion, until the capacity of the Croton water-shed to furnish a minimum supply of 250,000,000 gallons per day was determined from its meteorological history. The whole question was narrowed down to the selection of plans and means to secure sufficient storage, and to conduct

the water to the city. The plans for the utilization of the waters of the Croton basin, were therefore to combine a simplicity of construction, embracing economy in their design, large storage capacity and a conduit from the Croton River to New York City.

The erection of numerous small reservoirs for storage purposes, had been under consideration by the Board of Public Works prior to and during the years 1857 and 1858. Departing from the original plan, it was proposed in place of numerous small dams to build a large one on the Croton River at Quaker Bridge, about four and one-half miles above the mouth of the river, forming a reservoir of 3,635 acres in area, with a storage capacity of about 32,000,000,000 gallons, above the level of the proposed new aqueduct. This dam will receive the entire drainage of the 361 square miles of water-shed, including about twenty-three square miles below the present Croton Lake, not included in any previous plans or calculations. The most economical means for conducting the waters garnered by a system of reservoirs, or a single dam, was by means of a conduit to New York City, constructed of masonry, circular in form, with a capacity to deliver 250,000,000 gallons of water per day, the conduit to be in tunnel wherever possible. This plan has the advantage of being almost wholly in rock tunnel, securing the greatest possible strength and stability of structure, with the least cost for supervision and maintenance after completion. The prominent features of the entire plan therefore are a large reservoir to receive the entire drainage of the Croton water-shed, and capable of holding 32,000,000,000 gallons of water above the level of the aqueduct.

The Croton water-shed is located some thirty miles north of New York City, in the jurisdiction of the State of New York, having a catchment equal to an area of 361·8 square miles, with an average yearly rainfall equal to 45·97 inches, an average yearly flow of 135,400,000,000 gallons, or a daily flow of 371,600,000 gallons. This was determined from a meteorological history covering seventeen years.

It had long been felt that the capacity and supply of the old system erected when the population of the city was


PRESENT CROTON AQUEDUCT
NEW AQUEDUCT
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N.
E.
Nyack
Piermont
Tarrytown
Irving
Abbottsford
Irvington
Uniontown
JERSEY CITY
HOBOKEN
Weehawken
Bulls Ferry
Fort Lee
HUDSON
RIVER
Washington
HARLEM RIVER HIGH BRIDGE
Spuyten Duyvil
Yonkers
Glenwood
CROTON AQUEDUCT
CUT NO. 12
CUT NO. 14
CUT NO. 15
CUT NO. 16
CUT NO. 17
CITY OF NEW YORK
CENTRAL PARK
Reservoir
Tremont
Mt. Hope
NO. 21
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NO. 19
NO. 18
BROOKLYN
East River
LONG ISLAND CITY
Harlem River
MORRISANIA
Belmont
West Farms
Wakefield
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OLD RECEIVING RESERVOIR
NEW RESERVOIR
NEW GATE HOUSE
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SHAFT NO. 30
SHAFT NO. 29
SHAFT NO. 28
SHAFT NO. 27
SHAFT NO. 26(A)
SHAFT NO. 25(B)
SHAFT NO. 24(C)
SHAFT NO. 23(D)
SHAFT NO. 20(E)
SHAFT NO. 16(F)
SHAFT NO. 18
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SHAFT NO. 13
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CUT NO. 18
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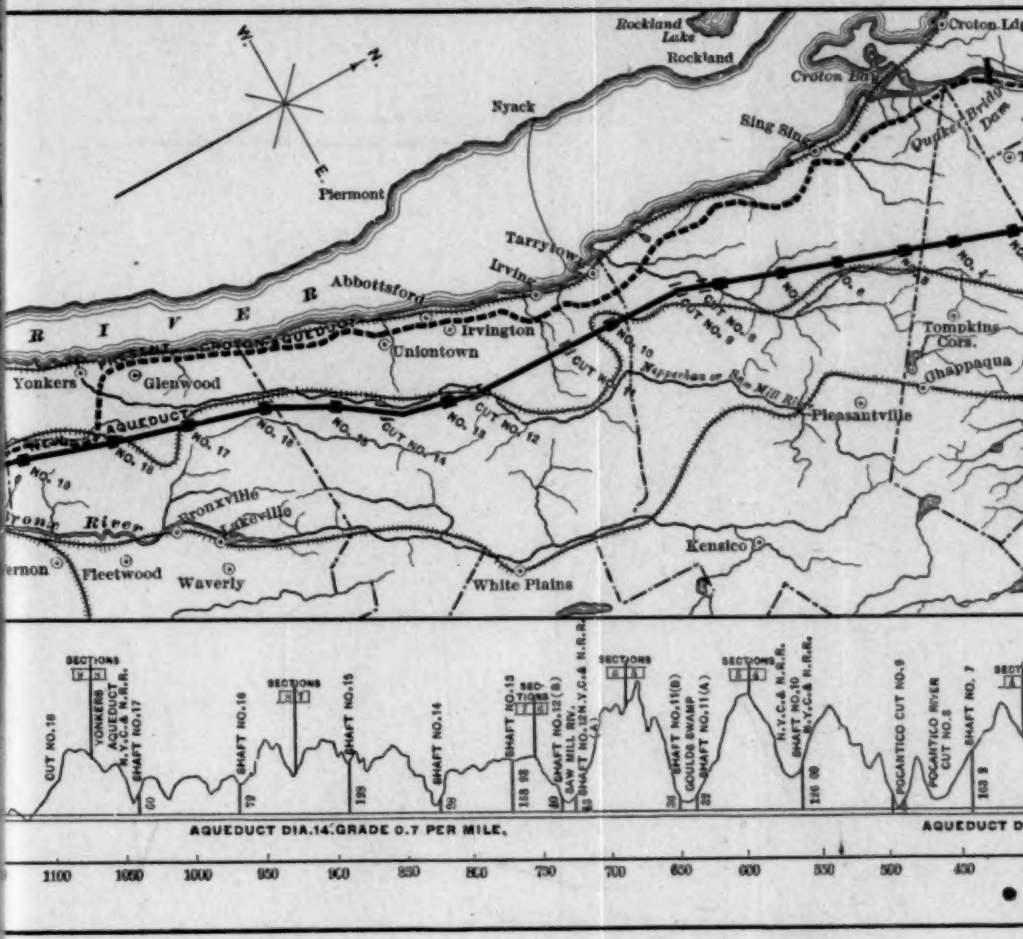
Rockland Lake
Rockland
Croton Bay
Croton Ldg
Nyack
Sing Sing
Quaker Bridge Dam
Piermont
Tarrytown
Irving
Abbottsford
R I V E R
Irvington
Unionton
Tompkins Cors.
Yonkers
Glenwood
Chappaqua
Pleasantville
AQUEDUCT
Bronx River
Bronxville
Tuckahoe
Fleetwood
Waverly
White Plains
Kensico
CUT NO. 18
YONKERS AQUEDUCT N.Y.C.& H.R.R. SHAFT NO.17
SHAFT NO.16
SHAFT NO.15
SHAFT NO.14
SHAFT NO.13
SAW MILL RIV.
SHAFT NO.12N.Y.C.& H.R.R. (A)
SHAFT NO.12 (B)
SHAFT NO.11(B) GOULDS SWAMP
SHAFT NO.11(A)
N.Y.C.& H.R.R. SHAFT NO.10 N.Y.C.& H.R.R.
POCANTICO CUT NO.9
POCANTICO RIVER CUT NO.8
SHAFT NO. 7
AQUEDUCT DIA.14. GRADE 0.7 PER MILE.
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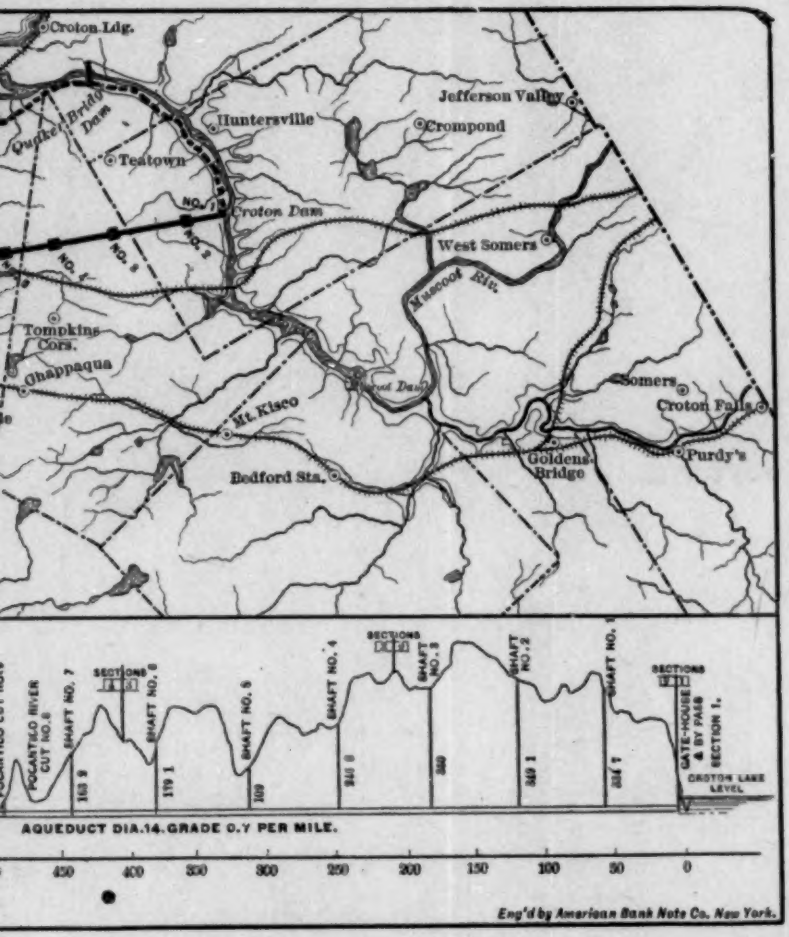
Croton Ldg.
Jefferson Valley
Huntersville
Crompond
Teatown
Croton Dam
West Somers
Muscoot Riv.
Tompkins Cors.
Ghappaqua
Somers
Croton Falls
Mt. Kisco
Purdy's
Goldens Bridge
Bedford Sta.
SECTIONS
SHAFT NO. 4
SHAFT NO. 3
SHAFT NO. 2
SHAFT NO. 1
SECTIONS
SECTIONS
SHAFT NO. 7
SHAFT NO. 6
SHAFT NO. 5
POCANTICO RIVER CUT NO. 8
GATE-HOUSE & BY PASS SECTION 1.
CROTON LAKE LEVEL
AQUEDUCT DIA. 14. GRADE 0.7 PER MILE.
450
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Eng'd by American Bank Note Co. New York.

350,000, were inadequate for the needs of a population of over 1,500,000, and that steps must be taken to increase the present supply. The Aqueduct Commission was accordingly created by the Legislature of New York in the year 1883, with power to provide an additional water supply.

Plans and specifications were presented by the Board of Public Works, specifying dams and reservoirs to be located at Quaker Bridge in the Croton River basin, with a dam at Muscoot Mountain in the upper Croton basin, together with a dam at Sodom, known as the West Branch Reservoir. After many public hearings and discussions the Commission decided that the new aqueduct should be constructed with a conduit having an inside clear area equal to that of a circle of the internal diameter of fourteen feet, locating its northern terminus at Croton Lake, and afterwards its southern terminus at Manhattan Valley.

The 9th of April, 1884, the plans relating to a conduit or tunnel thirty and three-fourths miles in length were adopted from gate house at One-hundred-and-thirty-fifth Street to Croton Lake. The water was to be conducted to the reservoir in Central Park from the One-hundred-and-thirty-fifth Street Gate House, by means of pipes, a distance of two and three-eighths miles, making the total length of Aqueduct thirty-three and one-eighth miles. The entire aqueduct is practically finished and ready for the introduction of water, its use being debarred only by some minor details. The water will enter the tunnel through a gate house located near the present Croton dam, this being constructed so as to receive water at an elevation of 140 feet above tide at the invert. Two other entrances are provided, one at elevation 166 and one at 184, discharging in Central Park Reservoir. The elevation of the flow line of Quaker Bridge Reservoir will be 200 feet above tide. The maximum elevation of the receiving reservoir in Central Park is 113 feet, the bottom seventy-nine feet. The elevation of point of discharge is 104 feet; the hydraulic grade line at Central Park 113 feet, the total fall from water level of greatest flow in the Aqueduct at Croton dam to high water in Central Park Reservoir being 33·8 feet, the distance being thirty-three and one-eighth miles.

The cross-section of the tunnel is in the shape of a horse-shoe, this modification from a circular cross-section having been made with a view to economy in blasting out the rock, the natural inclination of which was to assume a square shape rather than a circular one; the hydraulic area of cross-section remains the same as that adopted by the Commission, and extends without change twenty-five miles south of Croton Lake, with a hydraulic slope of 0·7 of a foot per mile, giving a velocity of four feet per second, and not being under flow pressure.

The remaining five miles being under flow pressure, by reason of a change in elevation, the diameter was reduced to twelve feet three inches. The hydraulic grade being raised increased the static head and the capacity to deliver the amount of water required permitted a decreased diameter. The tunnel approached the surface four times in the total distance, enabling the work to be prosecuted by means of open cuts. Headings were driven in the rock north and south of thirty-eight shafts together with the portals in open cuts.

	Feet.
The greatest depth of shaft from surface,	350
The least depth of shaft from surface,	28
Aggregate depth of shafts excavated,	4491
Average depth of tunnel underground,	170

The work of excavating the tunnel proper was begun March 7, 1885, and finished July 7, 1888, the time being three years and four months. The remarkably short time occupied in excavating the tunnel was due to the advance in mechanical appliances for drilling and excavating rock. An opportunity was afforded to demonstrate the efficiency of plants furnished by the most prominent manufacturers. The Ingersoll drills, gave by far the best satisfaction under all variations and conditions.

A record of monthly progress was kept, and from this the data of four months' working were selected from February 1st to June 3, 1886, choosing headings that were free from accidents, strikes and unusual delays. The results are given herewith:

	Shaft No.	*Feet.*
Best five headings, using Ingersoll drills exclusively,	23 –south,	219·8
	23 –north,	209·1
	22 –north,	197·5
	11a–north,	185·8
	4 –north,	182·4
		994·6
Average,		198·9

	Shaft No.	*Feet.*
Best five headings, using Rand drills exclusively,	20 –south,	152·5
	15 –south,	147·8
	14a–south,	134·0
	15 –north,	129·0
	19 –north,	119·0
		682·3
Average,		136·5

	Shaft No.	*Feet.*
Four headings, using Rand and Ingersoll drills together,	13 –north,	167·8
	18 –north,	164·5
	18½–south,	129·0
	12 –south,	106·8
		568·1
Average,		142·0

	Shaft No.	*Feet.*
Four headings, using Graydon & Denton drills exclusively,	16–south,	169·5
	17–south,	139·0
	17–north,	128·7
	16–north,	113·2
		550·4
Average,		137·5

A summary of the above figures shows the following result:

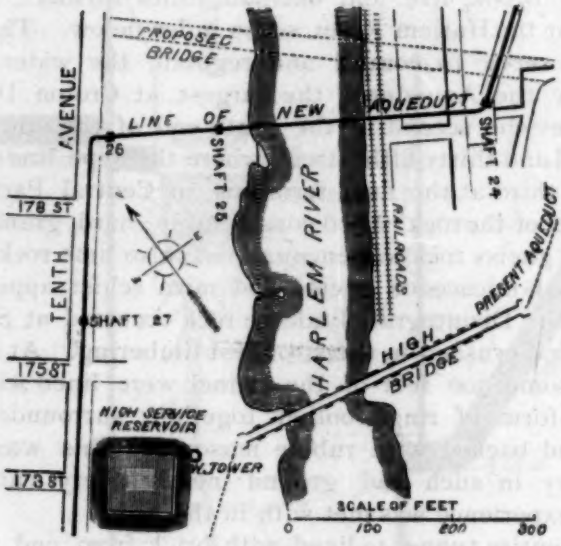
Average of five best headings driven with Ingersoll drills exclusively,	198·9 feet.
Average of five best headings driven with Rand drills exclusively,	136·5 "
Average of four headings driven with Ingersoll and Rand drills together,	142·0 "
Average of four headings driven with Gradon & Denton drills exclusively,	137·5 "

Highest average records in single heading for the last four months with different drills:

	Weekly.	*Monthly.*
With Ingersoll drills, exclusively, Shaft 23 South, .	48·8 feet.	219·8 feet.
With Graydon & Denton drills exclusively, Shaft 16 South, ...	37·7 "	169·5 "
With Rand and Ingersoll drills exclusively, Shaft 13 North, ...	37·3 "	167·8 "
With Rand drills exclusively, Shaft 20 South, . . .	33·9 "	152·5 "
Average monthly progress for the last four months on the entire line, forty-seven headings, . . .		141·8 "
Average monthly progress in thirty headings, using Ingersoll drills exclusively, ...		153·6 "
Average monthly progress in five headings using Ingersoll and Rand drills together, ...		130·9 "
Average monthly progress in seven headings using Rand drills exclusively, ...		122·8 "
Average monthly progress in four headings using Graydon & Denton drills exclusively, . . .		137·5 "

In passing under Gould Swamp the tunnel was driven on an incline with a hydraulic slope of fifteen per cent. to a depth of sixty feet below the main tunnel, then carried for a distance of 716 feet under and beneath the swamp, rising again by a vertical shaft to the level of main tunnel. A pumping house was erected at this shaft, No. 11 "B," for the purpose of clearing the siphon of water when the tunnel is to be emptied for examination. The diameter of this siphon is the same as that of the tunnel, the change of elevation in main tunnel, which occurs about twenty-five miles from Croton Lake, descending by an incline with a hydraulic slope of ten per cent. to a depth of sixty feet below the main tunnel. From this point the flow line is under pressure the remaining distance and the diameter is reduced to twelve feet, three inches, the flow due to increased velocity being about the same. Shaft No. 21, which is located near Jerome Race Course, twenty-five and one-fourth miles from Croton Lake, was designed with a view to the location of a reservoir at this point, discharging the water through this shaft. The total capacity of the tunnel not under flow pressure being 310,000,000 gallons per day, will admit of storage of the surplus water at this point, the elevation

of the surface at Shaft 21 being at hydraulic grade line. The hydraulic slope of the tunnel from the point at which the diameter changes to twelve feet, three inches, as far as the north bank of the Harlem River, is 0·7 of a foot per mile. At this point a vertical descent of 169 feet is made in order to pass beneath the Harlem River. The tunnel under the Harlem for a distance of 965 feet, being under flow pressure, was reduced to a diameter of ten feet, six inches, which was found to be all that was required.



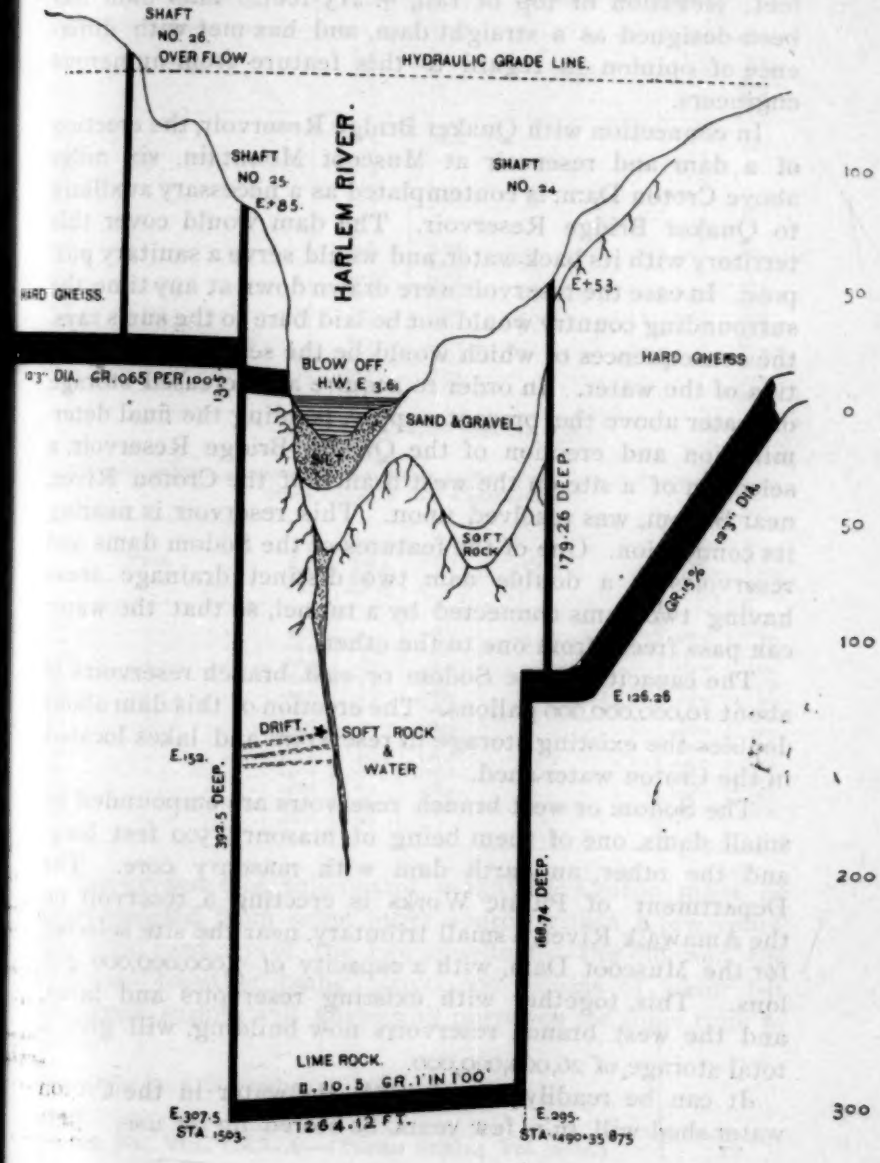
In this part, the hydraulic slope is one foot in 100 feet. The water is delivered to the tunnel through Shaft No. 25 rising 321 feet to an elevation nine feet above high-water mark; the tunnel being designed from this point to deliver the water at a gate house located at One-hundred-and-thirty-fifth Street, with a rising slope ·065 per 100 feet in order to drain that portion of the tunnel south of the Harlem into the Harlem River by an adit emptying into the river at Shaft 25, situated on the south bank of the Harlem. Shafts 24 and 25 were constructed for the purpose of draining the

tunnel under flow pressure north and south of the Harlem River, Shaft 25 also serving as a pumping station to free the siphon under the river. The tunnel ends at the gate house located at One-hundred-and-thirty-fifth Street, and the water is then conducted to the reservoir in Central Park by twelve lines of iron pipe, three feet in diameter. Four waste-weir gate houses are located on the line; one at Pocontico River, near Tarrytown, nine and one-half miles south of Croton Lake; the second, at Saw Mill River, six and one-fourth miles further south, near Ardsley; the third at Tibbets Brook, five and one-half miles further; and the fourth at the Harlem River, seven miles below. Three gate houses serve to control and regulate the water supply through the Aqueduct; the largest at Croton Dam, the entrance; the second at the south end of the tunnel, One-hundred-and-thirty-fifth Street, where the pipe line begins; and the third at the final terminus, in Central Park. The character of the rock varied considerably; hard, granitic, and syenitic gneiss rock was encountered; also lime rock; a soft laminated, micaceous gneiss and mica schist appeared in stretches. Disintegrated talcose rock occurred at Shaft 18 south, and crushed in the strongest timbering. At shaft 30 south, some 300 feet of the tunnel were lined with iron in the form of rings bolted together, surrounded with brick and backed with rubble masonry. This was found necessary in such bad ground; nearly every variety of tunnel experience was met with in this work.

The entire tunnel is lined with brick from end to end, forming a wall sixteen to twenty-four inches thick, and filled in from brick lining to rock face with rubble masonry. In order to obtain room for this lining the tunnel had to be excavated to a clear diameter equal to eighteen feet along the section, with an internal diameter of fourteen feet, and to fifteen feetin that part twelve feet, three inches in diameter.

By far the greatest feature of the system designed for an additional water supply, is the erection of Quaker Bridge Dam and Reservoir; its utility and necessity are conceded, though its construction has not been finished. Its successful and permanent construction will undoubtedly become

an established fact, in view of the real design and intention for which the New Aqueduct has been constructed. The total height at centre will be 265 feet; the width or thick-



ness at base will be 216 feet; width at top, 20 feet; its length at top, 1,500 feet; elevation of base, — 52 feet; elevation of flow line, + 200 feet; elevation of flood line, + 206 feet; elevation of top of rail, + 213 feet. This dam has been designed as a straight dam, and has met with difference of opinion in regard to this feature from numerous engineers.

In connection with Quaker Bridge Reservoir, the erection of a dam and reservoir at Muscoot Mountain, six miles above Croton Dam, is contemplated as a necessary auxiliary to Quaker Bridge Reservoir. The dam would cover this territory with its back-water, and would serve a sanitary purpose. In case the reservoir were drawn down at any time, the surrounding country would not be laid bare to the sun's rays, the consequences of which would be the serious contamination of the water. In order to acquire an increased storage of water above the present supply, pending the final determination and erection of the Quaker Bridge Reservoir, a selection of a site on the west branch of the Croton River, near Sodom, was resolved upon. This reservoir is nearing its completion. One of the features of the Sodom dams and reservoirs is a double dam, two distinct drainage areas having two dams connected by a tunnel, so that the water can pass freely from one to the other.

The capacity of the Sodom or east branch reservoirs is about 10,000,000,000 gallons. The erection of this dam about doubles the existing storage in reservoirs and lakes located in the Croton water-shed.

The Sodom or west branch reservoirs are empounded by small dams, one of them being of masonry, 500 feet long, and the other, an earth dam with masonry core. The Department of Public Works is erecting a reservoir on the Amawalk River, a small tributary, near the site selected for the Muscoot Dam, with a capacity of 7,000,000,000 gallons. This, together with existing reservoirs and lakes, and the west branch reservoirs now building, will give a total storage of 26,000,000,000.

It can be readily seen that all the water in the Croton water-shed will, in a few years, be stored up for use. This

has led to the investigation of the means and measured daily consumption of water in New York.

Estimate by Mean Curve of Consumption, Daily.		Measured Consumption.*	
Year.	Million Gallons.	Year.	Million Gallons.
1842	29·0	1842	12·0
1860	49·0		
1861	51·5		
1862	54·0		
1863	56·5	1863	54·4
1864	59·2		
1865	62·0		
1866	64·8	1866	66·0
1867	67·5	1867	72·0
1868	70·5	1868	78·0
1869	73·5	1869	75·0
1870	77·0	1870	70·0
1871	80·0	1871	79·0
1872	83·5	1872	81·0
1873	87·3	1873	88·0
1874	91·0	1874	92·0
1875	95·0	1875	95·0

* Commissioner's Report, August 12, 1879.

Estimate of Future Consumption of Water in New York City by Prolonging the Mean Curve of Past Consumption.

Year.	Million Gallons.	Increase Million Gallons.	Year.	Million Gallons.	Increase Million Gallons.
1876	98·0		1889	168·0	7·0
1877	102·0	4·0	1890	176·0	8·0
1878	106·0	4·0	1891	184·0	8·0
1879	110·5	4·5	1892	193·0	9·0
1880	115·0	4·5	1893	202·0	9·0
1881	120·0	5·0	1894	212·0	10·0
1882	125·0	5·0	1895	222·0	10·0
1883	130·5	5·5	1896	234·0	12·0
1884	136·0	5·5	1897	246·0	12·0
1885	142·0	6·0	1898	258·0	12·0
1886	148·0	6·0	1899	272·5	14·5
1887	154·0	6·0	1900	290·0	17·5
1888	161·0	7·0			

The evidence of this record is that the Croton must be supplemented from some other source within a few years. The total capacity of the two aqueducts—the old and the new one—together, being 350,000,000 gallons of water per day, their supply will answer all purposes for some time to come.

New York City, November 18, 1889.

PROCEEDINGS

OF THE

CHEMICAL SECTION,

OF THE

FRANKLIN INSTITUTE.

[*Stated Meeting, held at the* INSTITUTE, *Tuesday, Jan. 21, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, January 21, 1890.

Mr. T. C. PALMER, President, in the Chair.

Members present: Dr. L. B. Hall, Prof. E. F. Smith, Mr. Lee K. Frankel, Mr. W. W. Macfarlane, Mr. Philip S. Clarkson, Prof. E. H. Keiser, Dr. H. W. Jayne, Mr. A. W. Allen, Prof. N. Wiley Thomas, Mr. A. W. Whitney, Mr. L. J. Matos, Mr. G. L. Norris, Dr. L. I. Morris, Mr. W. H. Bower, Mr. L. E. Williams, Mr. A. T. Eastwick, Mr. J. H. Eastwick, Mr. Reuben Haines, Dr. Wm. C. Day, and two visitors.

The President called the attention of the Section to By-Law II, relating to the election of a committee on admissions.

On motion, it was voted that the present Committee on Admissions be continued for the current year.

The President then appointed Messrs. A. T. Eastwick and L. J. Matos members of the Finance Committee for the ensuing year, as required by By-Law VII.

The Treasurer reported that the subscriptions for the journals taken by the Section had been arranged for, and that the cost was somewhat less for the present than for the past year.

The resignation of Mr. Jacob Lychenheim was read and accepted by vote of the Section.

Messrs. W. W. Macfarlane and Philip S. Clarkson presented a paper on "The Action of Chlorine or Hæmatoxylin and the Extractive Matter of Logwood." It was referred for publication in the JOURNAL OF THE INSTITUTE, and in the *American Chemical Journal.*

A discussion of the paper by the President and the authors of the paper followed.

Mr. Lee K. Frankel exhibited a specimen of crystallized silver deposited on a platinum dish by electrolysis from a solution of nitrate; the current employed was very weak. The specimen was examined with much interest by the members.

Adjourned.

WM. C. DAY, *Secretary.*

NOTES AND COMMENTS.

CHEMISTRY.

RECENT RESEARCHES ON THE PREPARATION AND PROPERTIES OF FLUORINE. By H. Moissan (*Comptes Rendus*, **109**, 807, 861, 937).—Chemists have frequently but vainly attempted to prepare a fluoride of platinum, in the expectation that it would be easily decomposed by heat just as platinum chloride is decomposed. In 1856, Fremy wrote: "I have found it impossible by the reaction of hydrofluoric acid on the hydrated oxides of gold and platinum to prepare the anhydrous fluorides of those metals, which would probably have yielded fluorine by calcination."

This preparation, which is impossible from hydrofluoric acid and the hydroxides, for a reason that will be understood later, has become relatively easy by the direct combination of platinum and fluorine. I have already shown that heated platinum is readily attacked by fluorine.

In the present research it was first necessary to determine the conditions of temperature under which the union of platinum and fluorine could be brought about. When the fluorine is quite free from hydrofluoric acid it does not attack platinum in the form of wire or sheet at 100°, and the combination is quickly determined only at 500° to 600°. In the presence of a gaseous mixture of fluorine and hydrofluoric acid the metal is attacked more readily, as also by liquid hydrofluoric acid saturated with fluorine; this takes place in the electrolysis apparatus where the anode is rapidly corroded even at a temperature of 0°.

The fluoride of platinum is prepared by passing a rapid stream of purified fluorine from the electrolytic apparatus over bundles of platinum wires contained in a thick platinum or fluor spar tube heated to dull redness. As soon as the fluoride is formed, the bundle of wire is removed from the tube and placed in a perfectly dry glass tube. If a platinum tube be used in the preparation, a considerable quantity of liquid fluoride will remain in the apparatus.

The platinum fluoride forms dark red fused masses or small chamois-yellow crystals like anhydrous platinic chloride. It rapidly absorbs moisture from the atmosphere, and I have not been able to keep it a few months in carefully-dried and well-stopped bottles. Its reaction with water is most interesting. With a small quantity of water it at once dissolves, forming a fawn-colored solution that almost instantly becomes warm, hydrofluoric acid and platinic hydroxide being formed. If the quantity of water be large, the solution may be kept a short time without decomposition, but the latter takes place at once if the liquid be heated to boiling. This decomposition of platinic fluoride by water explains the impossibility of forming the compound in the wet way.

Platinic fluoride is at once decomposed into platinum and fluorine by a bright red heat, and the experiment can be made by rapidly heating the com-

pound to redness in a platinum tube closed at one end. A crystal of silicon held at the mouth of the tube then takes fire at ordinary temperature. The remaining platinum is found to be crystallized, this fact exemplifying the influence of fluorine in causing crystallization of minerals.

Analysis gave to the compound the composition PtF^4.

Gold fluoride was prepared in a manner similar to that by which the platinic chloride was obtained, and was found to be of a dark color, very hygroscopic, and decomposable by heat into metal and fluorine.

It remains now to discover an indirect method for the preparation of platinic fluoride, for this cannot be regarded as impossible, and the preparation of fluorine by purely chemical reaction will be made easy.

Density.—Pure fluorine being without action on platinum in the cold, an investigation of the physical constants of the element became possible. The gas was prepared by electrolysis in apparatus like that which has previously been described, but much larger. The U-tube was made of such size that 100 cc. of hydrofluoric acid could be used for a charge, and the disengaged fluorine was freed from hydrofluoric acid mechanically carried over by being passed first through a coil cooled to —50°, and then through tubes containing sodium fluoride.

The density was determined in platinum bottles containing about 100 cc., and weighing about seventy grams, the construction being such that a stream of gas could be passed through the bottle for any desired time. The bottle was first filled with dry nitrogen, and after the displacement of the nitrogen by fluorine and necessary weighing, the volume of any remaining nitrogen was determined. Three estimations gave the numbers 1·262, 1·265, 1·27 for the density of the gas, the mean being 1·265. The theoretical density for the atomic weight F=19, would be 1·316, and it may be here remarked, that the fact of a number lower than that required by theory having also been found for the density of phosphorous fluoride, it seems possible that determinations of the atomic weight of fluorine may have given a number somewhat higher than should be.

Color.—Its collected properties distinctly place fluorine at the head of the natural family, consisting of fluorine, chlorine, bromine, iodine. As the latter three elements possess color when in the gaseous state, and as the color gradually increases with the atomic weight, it was important to determine whether fluorine has a distinctive color. In our earlier researches, as the fluorine was examined against a white background behind the platinum tube, from which it was allowed to escape, no color was observed. This indication could not be considered as conclusive, and the color of fluorine has now been studied in platinum tubes fifty and 100 centimetres long, closed at the ends with perfectly transparent fluorspar. Short side tubes near the ends allowed the entrance and escape of the gas. The apparatus was first dried with care, and filled with fluorine by displacement until a crystal of silicon took fire at the opening of the tube, from which the gas was escaping. The side tubes were then closed by accurately-fitting platinum stoppers. The color of the contained gas was then examined against a white ground, comparison being

made with air contained in a glass tube of the same size as that of platinum, covered with black paper, and the ends closed with plain glass plates.

In a thickness of fifty centimetres, fluorine has a distinct greenish-yellow color, much less intense and more yellow than the color of chlorine examined in a stratum of similar thickness.

In a thickness of one metre, fluorine did not show absorption bands in the spectrum.

An experiment made on the fluorine in the fifty-centimetre tube gave an interesting result. When the tube was filled with fluorine a very small quantity of water was introduced by one of the side tubes. This water was partly decomposed by the fluorine with formation of hydrofluoric acid and ozone, and the latter gas was so concentrated that the interior of the tube assumed the deep indigo color found by Hautefeuille and Chappuis to be characteristic of concentrated ozone. In a short time the blue color faded and disappeared, owing to the gradual decomposition of the ozone by the external temperature. This reaction of fluorine on water is the first experiment in which ozone of such concentration has been formed at ordinary temperatures.

Spectrum.—The spectrum of fluorine was studied by the aid of an induction spark passed through the gas contained in a platinum tube, of which the ends were closed by fluorspar stoppers, through which passed thick platinum electrodes. A very short lateral tube, closed by a plate of transparent fluorspar, allowed the examination of the luminous gas. The following are the results, placed parallel with those obtained by Salet in a comparison of the spectra of the chloride and fluoride of silicon:

	Wave Lengths.	
	Moissan.	*Salet.*
Very faint,	749	—
" "	740	—
" "	734	—
Faint,	714	—
"	704	—
"	691	692
"	687·5	—
"	685·5	686
"	683·5	—
Bright,	677	678
"	640·5	640
"	634	—
"	623	623

Hence, the fluorine lines so far known are thirteen in number, and in the red part of the spectrum. I will add that with hydrofluoric acid, several bands are observed in the yellow and in the violet; but, these are not sharp, and are very wide, so that their position could not be exactly determined.

W. H. G.

On a General Method of Toning Photographic Silver Prints with Platinum and Metals of the Platinum Group.—By Pierre Mercier. (*Comptes Rendus*, **109**, 949.)—The attempts heretofore made to tone silver prints with platinum have not yielded satisfactory results. In

solutions of platinic chloride, the silver image rapidly becomes pale and disappears, for the silver is converted into chloride and is not replaced by platinum, that metal being simply reduced to platinous chloride. But if a solution of platinous chloride be employed, and, contrary to the requirements of a gold toning bath, this bath be rendered acid with mineral or vegetable acid, the silver prints immersed in it quickly acquire a black tone, passing through intermediate shades of an agreeable purple. Two atoms of silver are then replaced by one of platinum.

Palladium, iridium and osmium, under the same conditions as the platinum, furnish characteristic tones, and the general method of preparation of the baths appears to be based on the principle that toning by metals of the platinum group must be conducted in acid baths, and the metal must be in the lowest form of combination.

Platinum Toning.—The soluble and very stable chloroplatinites make excellent toning baths. Any of the alkaline chloroplatinites can be employed, the following formula serving as a type:

Potassium chloroplatinite,	1
Sulphuric acid,	5
Water,	1,000

The sulphuric acid may be replaced by hydrochloric acid, but since the latter renders the chloroplatinites more stable, its quantity should not be greater than 3 in 1,000, or, by organic acids, excepting such as formic, tartaric or oxalic, which exert a reducing action on the platinum salt, especially under the influence of light.

The toning bath may be prepared directly from platinic chloride by boiling it in the light with an appropriate reducing agent in the exact quantity required to reduce the salt to the platinous condition.

An excellent toning bath may be thus prepared by boiling in a glass flask a mixture of two grams platinic chloride in solution, with one gram sodium neutral tartrate until the yellow liquid assumes a dull gray color, then making up the solution to one litre and adding the proper quantity of acid.

Ruthenium and Osmium.—I have not succeeded in obtaining with ruthenium and osmium other tones than yellow, differing but little from the untoned prints.

Palladium.—A solution containing one gram sodium chloride, two grams palladious chloride, and 200 grams acetic acid to the litre of water rapidly blackens silver tones, but the paper takes a yellow tint which, even after bleaching by five per cent. ammonia water, reappears more or less rapidly after fixing, and destroys the value of the prints.

Iridium.—The iridium tone resembles that of gold. The bath may be prepared by dissolving one or two grams of iridium and platinum double chloride in one litre of water and acidifying as with platinum. Silver prints tone slowly in this bath, but the whites remain pure and hard; some soft violet tones are obtained.

Osmium.—This metal gives tones quite characteristic. The bath may be made by dissolving one or two grams of ammonia chlorosmite and

twenty grams acetic acid in a litre of water. Prints immersed in this bath take first a sienna brown tint; this color soon becomes modified, first, in the half-tones of the image, and changes to a more or less intense sky blue, which affects the whole print. If, instead of allowing the prints to become blue, they are withdrawn from the bath as soon as the blue begins to appear in the whites, a very curious result is obtained after the fixing. Besides the whites of the photograph, two tones are present, a light brown in the deep shadows, and a blue in the half-tones. With mineral acids the final tone obtained by the use of osmium is not blue but violet, and this tint appears even in the whites of the print. W. H. G.

THE AUSTRALIAN WATTLE. By Thomas B. Merry, U. S. Consular Report, No. 106, 1889, p. 253.—The growing scarcity of oak bark in the United States, and the substitution of all sorts of chemical agencies in the production of leather, leads to the inquiry as to whether other vegetable products cannot be found to fill its place. On a recent visit to Australia Commissioner Merry observed the extensive cultivation of the wattle in the colonies of New South Wales and Victoria. The two varieties most cultivated in those colonies are the black wattle (*Acacia decurrens*) and the broad-leaved wattle (*Acacia pycnantha*). Both these varieties are indigenous to an exceedingly dry climate and poor soil, and attain their growth in about six years. Some of the seeds were forwarded in January last to California, where they are already coming to a vigorous and healthy growth.

The black wattle produces the larger amount of tannic acid, and is, therefore, preferred by the trade in England, where its market value fluctuates from $38 to $40 per ton, according to the supply in the market. The bark is used for tanning, while the wood serves as fuel and for some other purposes.

The black wattle bark yields thirty to thirty-two per cent. tannin.

Broad-leaved wattle bark yields twenty-six to twenty-eight per cent. tannin.

Best Santa Cruz oak bark yields sixteen to eighteen per cent. tannin.

Siskey, or mountain oak bark yields fourteen to sixteen per cent. tannin.

While the broad-leaved wattle does not possess the tannic properties of the black variety, it has several advantages over the latter. It can withstand a greater degree of frosty weather than its congener. For this reason it is proposed that the black wattle be cultivated in the dry climate and arid soil of Arizona, New Mexico and Texas, as it is already in the southern counties of California, and that the broad-leaved variety be planted in the states of Louisiana, Georgia, Alabama, Mississippi and Arkansas, especially upon the gravelly soil away from the swamps.

The introduction of these trees into the Southern States is recommended for the following reasons:

"(1) They will not grow north of Mason and Dixon's line.

"(2) They are natives of an arid climate, and need comparatively little moisture. Hence they will grow on the treeless plains of Texas, New Mexico and Arizona, furnishing the cattle breeders of those regions with an abundance of good fuel, after removing the bark, which ought to yield $5 to the

acre, if properly planted and guarded while the trees are young and delicate.

"(3) They will be the means of strengthening a great industry, both in the North and South, by furnishing a new and unlooked-for supply of raw material, without which that industry must inevitably decline."

The Government is recommended to send to Melbourne and purchase 500 pounds—250 pounds of each of these varieties—of wattle seed, to be furnished to well-known agriculturists throughout the states and territories above described.

The planting directions are as follows: Reduce boiling water to a temperature of 140° F., steep the seeds therein till the water grows cold, and then immediately plant them in drills. Begin to thin them out gradually in the fall, and set them fourteen feet apart in the winter after they are two years old. At four, five and six years the trees should be ready to cut down, which should be done in April when the bark contains most sap. H. T.

BOOK NOTICES.

ADDRESS OF PROF. W. CROOKES BEFORE THE CHEMICAL SOCIETY. Annual General Meeting, March 21, 1889.

These addresses of Prof. Crookes have been to the chemist what the speeches of the Premier, at the annual dinners of the Lord Mayor are to the politician, a summary of vital importance of the immediate past, and a foreshadowing of the future.

A few years ago he gave the world his masterly genesis of the elements, which for originality and boldness of conception united with modesty and carefulness of statement, will remain one of the great thoughts enunciated in this century. It is not possible to produce monographs like this often, but Prof. Crookes' is one of those master minds which seem incapable of speaking without giving abundant food for reflection.

Passing over his statistical report of the doings of the Chemical Society, and his support of the abolition of the system of competitive examinations and of the system of sealing papers, both excellent arguments, we come to the chemical events of the year. In his own part of this history Dr. Crookes comes back again to the didymium and yttrium questions, but it is to give us new information in regard to them, and the other rare earths, which have been studied by him for so long. A table giving a condensed statement of the labors of Nilson and Krüss, Crookes and Boisbaudran, is startling from the names of elements and supposed parts of elements which have been added to our knowledge in the last few years. Didymium, divided by the former into nine different constituents, named by letters of the Greek alphabet is recognized as neodymium, praseodymium, and an unnamed body by Carl Auer. Decipium, samarium, lanthanum, erbium, philippium, holmium, thulium, dysprosium, yttrium, terbium, gadolinium, ytterbium and scandium make the reader, if he should have learned his chemistry a few years ago, think that he

is in another planet. But it is not in the researches only, or in the beautifully executed photographic plates of the spectra that the chief interest of this essay lies, but in the bearing which this painstaking work has upon the hypothesis of the genesis of elements. According to that hypothesis an all-pervading and practically homogeneous mass, subjected to constantly decreasing temperature and periodic change of electrical condition segregated into molecules of definite structure and density at irregular intervals. At some points many of these were produced, which thus resembled each other in chemical and physical features. At other times wide intervals separated the forming of elements. The inevitable conclusion was that there is as infinite a gradation between the possible so-called elements as between the shades of color in the spectrum, as the notes of sound, and if we have not found representatives of the intermediate members, it is partly because chemical research is not delicate enough to separate those nearly allied. By the process, however, of "fractionation," an application of method from organic to inorganic chemistry, it has been proved that the spectrum of the supposed element loses more and more of the lines which have been supposed to be indicative of it until the condition of "one band—one element" is approached. One set of lines disappear towards one end of the fractionation, and another set at the other. Is it not irresistibly suggested that some of these lines and bands belong to elements as yet unnamed or unknown? With great magnaminity Dr. Crookes prefers to stop giving names to all these bodies until we know more about them and to call them simply "meta-elements."

Incidentally the peculiar action of small amounts of lime and alumina on the spectra of the rarer earths is very interesting. Some of the lines of the earth are intensified, while others are neutralized, and this apparently independently of whether the lines are those generally considered characteristic or not. F.

THE SIEGE OF THE FORT OF ST. JOHN'S IN 1775. Written in French by Lucien Huot and translated by Geo. H. Flint. News Publishing House, St. John's. Pt. 2. 1889. R. 8vo. 25 pp.

This is a quaintly written sketch of the belligerent times just preceding the Revolution of the North American Colonies, which was inspired by Mr. Huot digging up near St. John's an unexploded shell, a blunderbuss, a metal stirrup, a bar shot and a grape shot.

It contains much local historical information concerning the feelings of the French, then recently become subjects of Great Britain, toward the dissatisfied Southern colonists.

Its author disclaims any military knowledge and relies on the work of the Rev. M. Verreau, *Invasion du Canada*, for much of his statistics. It concludes with a curious journal kept by one Foucher, supposed to have been a notary in Montreal, of the incidents of the siege of the fortification of St. John's by the "Bostonians" in 1775.

Thus early did Boston commence to be a paraphrase for the entire nation. F.

A DICTIONARY OF ELECTRICAL WORDS, TERMS AND PHRASES. By Edwin J. Houston, A.M. The W. J. Johnston Company, Limited, *Times* Building, New York, 1889.

The author has placed not only the electrical engineers, but also the great body of those who have to do with electrics, professionally or in a business way, under great obligation in the preparation of this very complete dictionary. The absence of a general work of reference, giving the exact meaning of the many new terms and phrases introduced into the terminology of this rapidly advancing branch of knowledge, has long been a serious inconvenience, and no more timely and welcome publication in this field could have been made than the dictionary. It is a substantial compensation to those who have so severely felt the need of such a work that at length it should have came from the pen of so experienced, thoroughly competent and caretaking an author as Prof. Houston, and his production will materially strengthen his reputation as an author. The work presents some unusual features, which would not be anticipated from its title, in being far more than a mere list of terms and phrases with definitions condensed into the smallest possible space. On the contrary, it is rather an explanatory and illustrated treatise, so fully and satisfactorily are the more important and difficult portions of the subject treated. The illustrations, with which the work is profusely embellished, substantially enhance the value of the book. Many of these illustrations are new, having been specially prepared for the work, and all are well executed. Taking it all in all, the work is one of the most useful of recent additions to technical literature.

In respect of typography the publishers have left little to be desired. W.

THE ICONOGRAPHIC ENCYCLOPÆDIA OF THE ARTS AND SCIENCES. Vol. V. Constructive Arts. Dr. Wm. H. Wahl, editor. Iconographic Publishing Company. Philadelphia. 1889.

This valuable contribution to the literature of the arts and sciences is a work of much labor and research. It has been the author's aim to condense the comprehensive subjects of BUILDING and ENGINEERING into a convenient compass and at the same time to represent fairly the various types which enter into this broad field of the useful arts. In this he has been unusually successful, as the scope of subjects is generous and the types well selected. From the limited space available, the descriptions must of necessity be meagre, yet they contain in most instances the essential data or principles which the investigator desires, and they are happily arranged in logical order and well referenced.

The section relating to BUILDING covers 145 quarto pages of attractive typography, richly embellished by nineteen plates, showing numerous styles of buildings, exterior and interior, ancient and modern, of all varieties of materials and with many details of construction.

The part relating to ENGINEERING contains 378 pages, treating of various modes of transportation on land, water and in air; also, of hydraulics, telegraphy and electricity and the numerous and varied structures necessary for these several departments of engineering construction. This part of the work

is profusely illustrated by sixty-one plates, containing excellent engravings of a great variety of subjects, which show graphically many of the complicated forms not to be conveyed by words. The book is one which should be found in every reference library. L. M. H.

STEAM ENGINE AND THE INDICATOR. By W. Barnet LeVan. Philadelphia, H. Carey Baird & Co. 1890.

This work contains a large fund of information heretofore to be had only by reading many books. The selections are made with good judgment and the matter clearly stated in terms within the easy comprehension of the general reader. The illustrations are clear and ample. The utility of the indicator and its proper application to engines is very fully and plainly shown. The description of gas engines and remarks on the economy attained by them are most opportune at this time, when their economy has reached that of steam engines of like sizes, and is a feature that must enhance the value of the work in the estimate of every reader. The explanations of the indicator diagrams and their showings of the performance of the functions in the engines from which they are taken, are in terms so plain as to be highly instructive to the working engineer, and must render the work popular.

The work is admirably and copiously indexed, rendering it extremely valuable as a book for ready reference for owners of power plant, as well as practical workmen. It seems to be just such a book as is at present required. In short, it is a practical book, clearly and ably written by a practical man on the subject he best understands. S. L. W.

CHEMICAL TECHNOLOGY, OR CHEMISTRY IN ITS APPLICATION TO ARTS AND MANUFACTURES. Edited by Edward Groves, F.R.S., editor of the Chemical Society, and William Thorp, B.S. With which is incorporated Richardson and Watt's Chemical Technology. Vol. 1. Fuel and its Application. By E. J. Mills, D.Sc., F.R.S., and F. J. Rowan, C.E. Edited by Charles E. Groves. With seven plates and 607 other illustrations. Philadelphia, P. Blakiston, Son & Co. 1889.

This splendid royal octavo of 802 pages, is a work of the highest order of merit and is distinguished both by its comprehensiveness and its fairness to all of the many sources of its information. It aims to consider all questions concerning combustion, both ultra, scientific and ultra-practical, and from this cause it suffers from the sudden transition which it is occasionally necessary to make from one point of view to the other. The work is so encyclopædic, that after having said that the editors have shown great erudition and good judgment in the main in the selections which they have made, its excellence of typography and proof-reading, are the only points left to admire.

In the more abstract part of the question, "thermics," the work is mathematical and scientific enough for a Maxwell or a Thompson, while its economical side is as well considered. With all this just and merited praise there is cause for some disappointment in the next chapter on the relative value of fuel, calorimeters and pyrometers.

Bunsen's calorimeter does not receive attention, and the whole treatment

of this subject is not clear enough to enable the neophyte to distinguish at once between the absolute heating effect and the number of heat units evolved—between calorific quantity and calorific intensity, and between the comparative calorific effects of equal volumes and of equal weights. This whole intricate subject which lies at the base of modern mechanical problems might be so systematized as to make it both more clear and more attractive.

Nevertheless it is not intended to disparage the volume by this criticism. It contains excellences in its practical portions, which more than offset their deficiencies. These are so numerous that it would take a whole article to enumerate and call attention to them.

Among them may be mentioned the introduction on fuel; the essay on coal; the effect of heat on fuels; wood, charcoal and coke; gaseous, liquid and minor fuels; prevention of smoke; domestic heating, including gas heating and cooking-stoves; hot-blast stoves; general principles of washing coal, and many other things.

It is without doubt the most useful and comprehensive book in the English language on fuels, and is a valuable acquisition to our standard books of reference. F.

Franklin Institute.

[*Proceedings of the Annual Meeting, held Wednesday, January 15, 1890.*]

HALL OF THE FRANKLIN INSTITUTE,
WEDNESDAY, January 15, 1890.

JOSEPH M. WILSON, President, in the Chair.

Present, 78 members and fourteen visitors.

Additions to membership since last meeting, 27.

The Annual Reports of the Board of Managers, of the Standing Committees and of the Chemical Section were presented and accepted.

ANNUAL REPORT OF THE BOARD OF MANAGERS OF THE FRANKLIN INSTITUTE.
(For the year 1889.)

The Board of Managers of the FRANKLIN INSTITUTE of the State of Pennsylvania for the Promotion of the Mechanic Arts, respectfully presents the following report of the operations of the INSTITUTE for the year 1889:

MEMBERS.

Membership at the close of 1888, ...	2,081	
Number of new members elected who have paid their dues, ...	410	
		2,491
Lost by death or resignation, ...	69	
Dropped for non-payment of dues, ...	198	
		267
Total membership at close of 1889, ...		2,224

FINANCIAL STATEMENT.

Balance on hand January 1, 1889,		$11,417 49
Receipts:		
Contributions of members,	$9,738 50	
Certificates of stock, second class,	60 00	
Interest on investments of INSTITUTE'S funds,	1,584 00	
Interest on investments of Building Fund,	245 00	
Cash from other sources,	9,417 98	
		21,045 48
		$32,462 97
Payments:		
Committee on Library,	$1,706 80	
Committee on Instruction,	2,156 33	
Curators,	2,420 96	
Salaries and wages,	4,027 96	
Insurance,	375 00	
Fund for completion of serials,	161 12	
Temporary loan,	2,000 00	
Interest on temporary loan,	92 19	
Investment Building Fund,	5,557 50	
" Bloomfield H. Moore Fund,	5,000 00	
Other expenditures,	6,792 78	
		30,290 64
Balance on hand December 31, 1889,		$2,172 33

The INSTITUTE has paid off this year the temporary loan of $2,000, and has had extraordinary expenses in repairs and additions to the building, and for refurnishing, amounting to nearly $1,000. It will be seen, therefore, that the financial condition of the INSTITUTE is considerably improved, principally owing to the additions to the membership that were made during the year.

LIBRARY.

The annual report of the Committee on Library shows that 3,732 bound and unbound volumes, pamphlets, maps, etc., were added during the year. The new system of rules regulating the use of the Library by non-members has now been in force for nearly two years, and has fully demonstrated its usefulness.

The members are referred by the Board to the report of the Committee on Library for details of the condition and operations of this important branch of the INSTITUTE.

THE JOURNAL.

The JOURNAL during the past year was not only self-sustaining, but, greatly to the satisfaction of the Board, it has yielded a moderate profit. In view of the fact that the JOURNAL is devoted almost exclusively to the publication of

scientific and technical subjects directly emanating from the INSTITUTE, it is noteworthy that its financial support is derived almost wholly from outside sources.

The Board again takes occasion to commend the JOURNAL to the attention of the members as worthy of more generous support than it now receives at their hands.

LECTURES.

The Committee on Instruction has succeeded in arranging a varied and interesting course of lectures, and it gives the Board much satisfaction to note the willingness exhibited by eminent men to come from a distance to Philadelphia to lecture before the INSTITUTE without compensation or other advantages than those to be derived from the publication of their best thoughts in the JOURNAL, and their re-publication into other technical papers.

During the past year the following lectures were delivered, viz :

January	21.	Mr. Robert W. Hunt, on "The Manufacture of Bessemer Steels."
January	28.	Prof. Samuel P. Sadtler, on "The Debt of Medical and Sanitary Science to Synthetic Chemistry."
February	11.	Prof. Chas. F. Himes, on "Amateur Photography."
February	18.	Dr. T. Sterry Hunt, on "Some New Points in Chemical Theory."
February	25.	Dr. L. Webster Fox, on "Blindness and the Blind."
March	4.	Dr. H. A. Slocum, on "Unwholesome Trades and Occupations."
March	11.	Mr. Patrick B. Delaney, on "Cable Telegraphy."
March	18.	Mr. Andrew Carnegie, on "The Industries of Pennsylvania."
November	4.	Daniel Ammen, U.S.N., on "Proposed American Isthmian Canal Routes."
November	8.	Prof. Lewis M. Haupt, on "Municipal Engineering."
November	11.	Prof. Persifor Frazer, on "Mexico."
November	15.	Prof. W. Le Conte Stevens, on "The Development of Aëronautics."
November	18.	Dr. H. Hensoldt, on "Natural History in Elementary Schools."
November	22.	Mr. Chas. Heber Clark, on "Work, Waste and Wages."
November	25.	Prof. C. Herschel Koyl, on "The Development of Railroad Signaling."
November	29.	Mr. C. John Hexamer, on "A Descriptive and Illustrated Sketch of Canada."
December	2.	Prof. C. Hanford Henderson, on "A Lay Sermon on Chemistry."
December	6.	Mr. Fred. E. Ives, on "The Optical Lantern as a Means of Demonstration."
December	9.	Mr. T. Dunkin Paret, on "Emery Wheels."
December	13.	Mr. Wm. M. Barr, on "The Duty of Pumping Engines."

December 16. Mr. Ralph W. Pope, on "Electricity, its Past, Present and Future."

December 20. Mr. Thomas Pray, on "What Does a Steam Horse-Power Cost?"

The attendance at the lectures during the past year exhibits a notable improvement over that of previous years.

DRAWING SCHOOL.

The Drawing School has continued in a satisfactory condition, both in regard to efficiency and number of pupils:

The attendance at the Spring term of 1889 was, ...	175
And at the Winter term, ...	212
Total attendance for the year, ...	387

These figures exhibit an increase of five over those of the previous year.

COMMITTEE ON SCIENCE AND THE ARTS.

The work of the Committee on Science and the Arts during the past year shows a decided improvement, both in the amount of work performed and in the character of the subjects investigated. The Committee during the past year examined and made report upon sixty applications and has now under consideration twenty-nine cases. In three cases, the Committee awarded the Elliott Cresson Medal, and in nineteen cases recommended to the Board of City Trusts the award of the John Scott Legacy Premium and Medal (which recommendations were all approved). In one case a Certificate of Merit was awarded.

Additional details of interest will be found in the report of the Chairman.

SECTIONS.

The Chemical Section is in a flourishing condition. It has added substantially to its membership during the past year, and the number and importance of the papers presented at the meetings, as shown by the records, exhibit a notable improvement. The detailed work of the Section may be found in its Annual Report.

STATE WEATHER SERVICE.

The grant by the State Legislature of an appropriation of $5,000 for two years for continuing the work of the State Weather Service, organized and conducted under the direction of the Committee on Meteorology, has enabled the Committee to do much in the direction of improving the organization and increasing the efficiency of the Service. The publications of the Service have been steadily increasing in value, and with the equipment of a number of its stations with self-registering meteorological apparatus, which is in contemplation, the value of the work accomplished will be substantially increased.

There appears to be general satisfaction with the manner in which the

Service is being conducted. In its last Annual Report, the Committee has published, and thus preserved from loss, a great amount of scattered material collected by observers throughout the State during a period going back nearly to the foundation of the colony. For the preservation of these valuable data the Service has earned the thanks of the INSTITUTE and of the people of the State.

REORGANIZATION AND FUTURE WORK.

Attention is particularly directed to the large increase in the membership during the year. Quite a number have been dropped for non-payment of dues and some have resigned, so that the total increase does not appear as much as it otherwise would, but the percentage of non-effective members is very much reduced. The movement for promoting the increase of the membership, which was initiated in October of 1888, by the appointment of a special committee, and began to show good results almost immediately, has progressed with very marked success. The result only shows what may be done with a little effort. One single member has brought in over 100 new members, yet very many have brought none.

If each member of the INSTITUTE would bring in only one new member, it would put the INSTITUTE into excellent shape. Even as it is, the improvement in its financial condition for the past year is very gratifying. It is hoped that the Committee on Membership will not relax its efforts, but will continue to push the work with the same enthusiasm that it has shown during the past year. Vacancies will always occur by deaths, resignations and delinquencies, and these must be more than supplied to produce an actual increase in the membership, as is needed.

Something has been accomplished in reference to subscriptions to the Building Fund, but not much. The machinery is ready, the books are opened and subscriptions are now needed. The Committee for Reorganization has been increased to 100, selected from among those members of the INSTITUTE who were deemed most interested and active in its progress. It has been judged, very properly, that before an appeal can be made to the members at large or to the general public, the members of the Committee should give substantial testimony of their interest in the work, and with this view circulars were sent out to them with a form of subscription. Some very liberal responses were made and the subscriptions at present amount to nearly $30,000, but from a large number of the Committee nothing has been heard. An endeavor will be made at an early day to visit all of those who have not yet subscribed, and to urge upon them the necessity of showing zeal and interest in the work in one form or another. Let it be understood, however, that large subscriptions are not expected from those whose means are limited. If each will give as he conscientiously feels he can do, it will be enough, but it should be something. So far, the subscriptions have been conditioned upon the sum of $100,000 being subscribed before the end of the year 1890, and a suitable site secured for the new building. Some members have expressed a preference for making small annual cash subscriptions to the Building Fund, instead of a contribution of this kind. To meet the

views of these members, a subscription book has been opened for annual cash contributions, and subscriptions will be received either way or both ways. The success or failure of the movement now depends upon the members of the INSTITUTE themselves. This should be fairly understood; that it is not a personal matter with the President or the Sub-committee on Subscriptions, to be individually urged upon each member. If the members of the INSTITUTE do not want new buildings, it is for them to say so. It rests entirely with them. After the Committee on Reorganization has substantially shown its thorough interest in the matter, then, and only then, can the Subscription Committee go out among the friends of the INSTITUTE with good heart and ask and urge for subscriptions from them. Members of the INSTITUTE, if you are lukewarm about this, let the result rest upon you. With *your* efforts the work is *sure* to succeed, without them it is *sure* to fail. There is no more certain way of insuring a failure than to say that you know it will not succeed, and, therefore, you will not give anything towards it. You not only throw cold water upon it, but you do your best to make it fail. Under such circumstances no plan will succeed. But if you will help it, no matter how little, it will be sure to have success. It is not the few large subscriptions that will do it, but the many small ones. Never mind about the particular form of plan adopted for taking subscriptions. Some are hasty to find fault and to want something different. Different minds have different views; all cannot be satisfied, and one plan must be adopted. Do not go into details, but if you have the interest of the INSTITUTE at heart go ahead and help it with all your might and main, no matter what the detail of the plan. Then, and then only will it be sure of success.

By order of the Board,

JOSEPH M. WILSON,
President.

THE COMMITTEE ON THE LIBRARY

Respectfully reports that there has been added to the Library during the year 1889:

Bound volumes, ...	1,145
Unbound volumes, ...	398
Making a total addition of, ...	1,543
Which added to the number of volumes at the close of 1888,	31,762
Gives the number of volumes	33,305

Bound and unbound in the Library at the end of the year 1889.

The number of pamphlets in the Library December 31, 1889, was	19,622

Of which 15,953 are catalogued and accessible for reference.

The maps and charts number	1,783
Designs and drawings, ...	603

Photographs and lithographs,	1,039
The duplicate volumes, bound and unbound, number	2,536
" " pamphlets,	5,554
" " loose periodicals,	6,539
" " maps and charts,	166

A number of valuable and important serials have been completed during the past year, some of which were obtained with difficulty.

B. H. MOORE FUND.—During the year 134 volumes were added to this collection. The books purchased with this fund bear an appropriate label, and a register is kept of them, with date of purchase and cost.

The number of receipts filed by non-members of the INSTITUTE for books used in the Library was 1,257; 1,689 volumes were issued to members for home use.

The exchanges for the JOURNAL OF THE INSTITUTE number 376.

The regulation of the Committee requiring a receipt to be given for books consulted in the Library, or taken out for home use, has proved of so much service to the Librarian in keeping an oversight over them, that the custom will be continued.

CHARLES BULLOCK,
Chairman of Committee on the Library.

January 9, 1890.

COMMITTEE ON SCIENCE AND THE ARTS.

The Chairman of the Committee on Science and the Arts respectfully reports that the past year of the Committee, commencing with February, 1889, and terminating with January of this year, has been one of unusual activity.

Under the plan of reorganization of this Committee, effected three years since, the conduct of all scientific investigations and reports, other than meteorological and chemical subjects, and all awards by the INSTITUTE, devolve on this Committee. With this fact in view a more voluminous report of the operations of the year should not appear unseemly, and no apology therefor is necessary.

During this period 132 applications have been submitted to the Committee for examination and report.

Of these, forty-three applications have been dismissed or rejected as not entitled to consideration, or withdrawn by the applicants.

Upon ten of these applications, advisory reports have been made to the applicants.

Upon fifty applications, examinations and reports have been made and finally acted upon.

The award of the John Scott Legacy Premium and Medal has been recommended in nineteen cases. The Elliott-Cresson Medal has been awarded in three cases, and one Certificate of Merit has been awarded.

Twenty-nine applications remain pending, most of them being recent applications, and many of them awaiting data on the part of the applicants, in response to requirements of the Committee.

Protests against two of the awards of the Committee have been received, which protests were unsustained by any reasons or evidences sufficient to change the convictions of the Committee and the original reports were therefore affirmed.

In appointing sub-committees for the examination of the above applications, nearly one hundred members have been associated in the several committees, with those elected by the INSTITUTE, securing, in many cases, the benefit of skill and knowledge of gentlemen best conversant with the various subjects, the effect of which appears in the improved character of the reports and in rendering many of the members conversant with the operations and methods of the Committee. From the gentlemen thus associated, the Committee has been frequently recruited to fill vacanies caused by resignation, and some of the committees have included gentlemen pre-eminently qualified to examine the subjects of applications, who were not members of the INSTITUTE at the time of their appointment, but who showed their appreciation of the INSTITUTE by becoming members, and thus, in many cases bringing gentlemen into desirable and pleasant personal intercourse, who had heretofore only known each other by reputation.

By this means, during the year, more than thrice the number of applications have been examined, as compared with the preceding year, and in no case does it appear that any of the work has been done in a perfunctory manner; in fact, the records of the Committee are replete with evidences of painstaking care and intelligent industry of the members generally.

Ten of the reports were upon subjects of such general public interest and importance that the reports included a history of the branches of arts in which the inventions were made and were illustrated and published in the JOURNAL OF THE INSTITUTE, causing a demand and sale for about 8,000 copies of the JOURNAL beyond the usual edition. A considerable increase of revenue to the INSTITUTE through the Committee on Publications has resulted therefrom.

In most cases the reports of the sub-committees have been illustrated to the General Committee by lantern slides and to each report copies of all data before the sub-committees have been appended.

The outlay of the Committee for clerical expenses in engrossing reports, printing and mailing, have increased somewhat and at first sight are apparently greater, because the illustrations and copies of patents for reference primarily are paid from the appropriations made by the Board of Managers, which in the last year amounted to about $250, but much of this expense is returned to the treasury by the payments made for illustrations by applicants, and a return also appears through the accounts of the Committee on Publications for the advertising of awards and the profit from the sales of increased editions of the JOURNAL containing reports of the Committee, so that on the whole this Committee is materially augmenting the income of the INSTITUTE.

In pursuing the line of investigation and exhaustive reports on important inventions, members of the Committee have often been met by a criticism that such reports benefit private interests, and, however well deserved,

should be paid for as expert work. It will readily be apparent that in the manner above indicated the work *is paid for*, and the pay goes directly into the treasury of the INSTITUTE, where it properly belongs; and this can be no loss to the members that make such reports, for it is simply incredible that any person of sufficient intelligence to prepare a good report, could fail to get far more valuable information from the many other equally capable members contributing to our stock of knowledge; beside which there is no member who has carefully prepared an able report on an important subject, who is not amply repaid by having the authorship accredited to him in publication.

Up to the commencement of the year just closed, the reports of the sub-committees, since its organization in 1834, have been simply stowed away with more or less care (too often with less), without any method and with no means of finding many of them. No clue to their contents existed beyond the recollection of the members of the Committee, thus leaving the evidences collated by the labors of the earlier members of the Committee lost to the present generation.

The Committee being impressed with the fact that such a state of things, if continued, must go from bad to worse, have had all of the reports carefully classified according to their subject-matter, conformably to the method of classification followed in the U. S. Patent Office, so that now every report is indexed and catalogued:

(1) Numerically and chronologically.

(2) Alphabetically, by the name of the applicant.

(3) Alphabetically, by the name of the inventor.

(4) Alphabetically, by the title of the invention as filed by the applicant, and

(5) Alphabetically, by the class and sub-class of invention to which it is referable by its subject-matter.

This system of indexing renders the contents of the report usefully accessible for reference and valuable in proving the early condition of many arts, which recent inventions not infrequently repeat. (In one instance, to our certain knowledge, the information in an old report caused a complainant to vacate several suits for infringement, although he had previously been offered a liberal sum as a compromise and refused it.*)

This work, although a large task to bring up to date, can now be continued regularly with comparative ease.

The entire expense of this work, for clerical services, has been defrayed in the Committee without drawing upon the treasury of the INSTITUTE for anything other than the stationery required.

The indices thus prepared, it is intended to refer to the Committee on Publications, with discretion to act upon the propriety of publishing the same as an appendix to the JOURNAL; it is estimated that it will make a book of about eighty pages of JOURNAL size, say about the size of one monthly number of the JOURNAL.

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* Murphy *vs.* the Hamilton Rubber Works; Murphy *vs.* Trenton Rubber Co., and nine other defendant corporations.

Appended to this report* will be found statements in full detail of the subjects examined, the awards made, and the names of the gentlemen who have assisted the elected Committee as associate members, which detailed statements, while not interesting reading, may prove valuable for future reference.

In conclusion, in behalf of the Committee, the Chairman feels justified in asserting that the work of the Committee confirms the sound judgment of the INSTITUTE in reorganizing the Committee three years ago, and the Committee besides having brought to light all reports up to date, which had, by want of system, for years passed out of knowledge, and practically gone to waste, has demonstrated its capacity for both improved quality and increased quantity of work under greater safeguards against mistakes.

Respectfully submitted,

S. LLOYD WIEGAND,
Chairman.

REPORT OF THE CHEMICAL SECTION OF THE FRANKLIN INSTITUTE.

[For the year 1889.]

Mr. JOSEPH M. WILSON, President FRANKLIN INSTITUTE.

SIR:—I have the honor to submit the following report of the proceedings of the Chemical Section for the year 1889.

It is with feelings of the greatest satisfaction on the part of its members that the Section can report the year just closed as by far exceeding any previous year in each and all the elements which go toward making up the sum total of sucess in the work of a scientific body.

The work of the Section was prosecuted with the aid of the following

OFFICERS.

President—Mr. H. Pemberton, Jr.
Vice-Presidents—Dr. Samuel C. Hooker and Mr. T. C. Palmer.
Secretary—Dr. Wm. C. Day.
Treasurer—Dr. H. W. Jayne.
Conservator—Dr. Wm. H. Wahl.

Stated meetings were held on the third Tuesdays of January, February, March, April, May, June, September, October, November and December, making in all ten meetings during the year, as required by the By-Laws of the Section.

MEMBERSHIP.

The number of members on the Treasurer's books January 1, 1889, was 55; of this number 5 were dropped for non-payment of dues and 3 resigned; 24 new members were added to the list, making a total at the end of the year of 71, thus showing a gain of 16 members, or nearly 30 per cent.

* Not published.

FINANCIAL CONDITION.

The report of the Treasurer, submitted to the Section at its last meeting, shows a total of receipts from various sources during the year amounting to $181.35; disbursements amounting to $89.85, thus leaving a cash balance of $91.50 in the hands of the Treasurer at the end of the year.

ATTENDANCE AT MEETINGS.

Early in the year the attendance at the meetings of the Section increased to such an extent that the rooms adjoining the Library, in which the meetings had hitherto been held, proved to be entirely inadequate, thus necessitating the adoption of the Lecture-hall of the INSTITUTE as the future meeting-place. In addition to the attendance of regular members there has been a very liberal sprinkling of visitors at a majority of the meetings.

With the idea of increasing the general usefulness of the Section, the subject of a revision of the By-Laws was taken up in the latter part of the preceding year, and after due and careful consideration by the Section as a a whole the subject was referred to a committee for action; the By-Laws, as revised by this Committee, were, after a few alterations, finally adopted by the Section at the meeting held March 19, 1889. There is a general feeling of satisfaction on the part of the members with the By-Laws as they now stand, and it is believed that by this act of revision permanent good has been accomplished for the future interests of the Section.

At the meeting held January 15, 1889, Dr. Wahl announced, as Secretary of the INSTITUTE, "that scientific papers read before the Section could be published in the JOURNAL OF THE INSTITUTE simultaneously with other journals, and that such articles would be continuously paged, so as to form an independent work, which could be bound and issued as such by the Section." It affords the Section great pleasure to submit with this report a copy of the separate volume referred to.

With the idea of increasing the interest taken by chemists in the JOURNAL OF THE INSTITUTE, a Standing Committee on Abstracts was appointed at the first meeting of the year; the duty of this Committee is to select articles of general scientific interest from the various chemical journals of the world, and to assign such for abstraction to various members of a volunteer committee. As a result of this step a large number of interesting abstracts has appeared in the JOURNAL during the past year.

While the Section recognizes the fact that much good is to be accomplished by regular meetings of scientific men, for the purposes of discussing the interesting scientific questions of the day, and in exchanging views and opinions in regard to the numerous discoveries made in different parts of the scientific world, it places a much higher value upon the results of original investigation on the part of its members. Special efforts have been made during the past year to stimulate original investigation within the Section; the result has been most gratifying and is embodied in the following statement:

No less than twenty-nine papers have been read for the first time before

the Section, giving the results of original investigation on the part of the members. A large number of other papers carefully prepared, and showing in detail the present state of knowledge in various subjects of technical as well as purely scientific interest, have also been presented and listened to with marked interest.

The prospects for even more encouraging results for the coming year could hardly be brighter. Very respectfully submitted,

WM. C. DAY,
Secretary.

Mr. S. LLOYD WIEGAND gave a brief description, with suitable illustrations, of recent advances in type-setting machines, using the Linotype and the Thorne type-setting machine as typical examples.

Mr. H. H. SUPLEE exhibited and described a number of views of the steamship *Great Eastern*, now being broken up.

The Secretary presented his Annual Report of Technical Progress. He exhibited specimens of *repoussé* work in metal made with the Hobson hydraulic shaping press, and specimens of the aluminium products of the Pittsburgh Reduction Company.

Following is a list of officers and managers of the INSTITUTE and members of the Committee on Science and the Arts, elected at the annual election held Wednesday, January 15, 1890:

For *President* (to serve one year), ... JOSEPH M. WILSON.
For *Vice-President* (to serve three years), . CHARLES BULLOCK.
For *Secretary* (to serve one year), ... WM. H. WAHL.
For *Treasurer* (to serve one year), . . . SAMUEL SARTAIN.
For *Auditor* (to serve three years), . . . SAMUEL H. NEEDLES.

For *Managers* (to serve three years):

CHAS. H. BANES,
F. LYNWOOD GARRISON.
WASHINGTON JONES,
EDWARD LONGSTRETH,
THEO. D. RAND,
COLEMAN SELLERS,
STACEY REEVES,
ISAAC NORRIS, JR.

For members of the *Committee on Science and the Arts* (to serve three years):

ARTHUR BEARDSLEY,
HUGO BILGRAM,
JOHN H. COOPER,
G. M. ELDRIDGE,
N. H. EDGERTON,
J. H. EASTWICK,
F. LYNWOOD GARRISON,
RUFUS HILL,
JOHN HALL,
WM. HARKNESS, JR.,
GEO. A. KOENIG,
E. ALEX. SCOTT,
H. W. SPANGLER,
COLEMAN SELLERS,
WM. H. WAHL.

Adjourned.

WM. H. WAHL, *Secretary.*